Beyond Forest Conservation: Exploring the Impact of REDD+ on Livelihood and Detection of Forest Cover Change in Cross River State, Nigeria.

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Submitted to Swansea University in partial fulfilment of the requirements
for the Degree of Master by Research

Department of Geography
Swansea University
June 2022.

Word Count: 33, 895

Abstract

To address the issue of climate change, the United Nations Framework Convention on Climate Change introduced REDD+ “Reducing Emissions from Deforestation and Forest Degradation”. Nigeria has lost 90% of its natural forest. The Cross River State has the largest proportion of the remaining tropical forests. In 2010, Nigeria joined the UN-REDD scheme to contribute to global climate change mitigation. Accordingly, the CRS became Nigeria's first REDD+ pilot state. Logging was therefore prohibited. A mixed-methods approach was used in this study to assess the impact of REDD+ in CRS. It involved key informant interviews, questionnaires, and remote sensing data. Sampling was done using a purposive and snowball approach. Autoregressive integrated moving average analysis was used to develop a model to predict the post-intervention period dependent on time. A simple linear regression of the residual values of the Normalized Difference Vegetation Index was used to determine the impact of the REDD+ program on the forest cover. The results indicate a slight positive impact. Time accounted for a 3.5% variation in vegetation cover of Akamkpa and Boki Local Government Areas after ten years of REDD+. However, more variables could be added to improve the model and identify the major drivers explaining variations in vegetation gain. A parametric t-test was also conducted, and the result was significant at ($p<0.05$) when compared to the ordinary least squares regression. Agriculture was the main economic activity in the study area. Furthermore, many respondents preferred agricultural skills\training and 67% desired more land for farming. This can have a detrimental effect on the CRS forest resources. The study proposes that future conservation efforts should consider forest community capacity-building preference before project commencement. Moreover, smallholder farmers should be empowered and trained to maximize yields on existing agricultural lands. Information, education, and communication materials should be made in local languages to raise awareness about REDD+, climate change, and forest conservation in Nigeria.

Keywords: REDD+: Remote sensing, Cross River State, Vegetation cover, Benefit-sharing, Livelihood, Forest communities.

Declarations

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed.........................[redacted]

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This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

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I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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The University's ethical procedures have been followed and, where appropriate, that ethical approval has been granted.

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Acknowledgement

I honour God Almighty for the successful completion of my thesis. My profound gratitude goes to my amazing research supervisors, Dr Yeran Sun and Dr Iain Robertson of the Department of Geography, Swansea University. Their guidance, instructions, and suggestions contributed immensely to this thesis. It was a great privilege to study under their guidance. Dr Yeran taught me how to extract the Normalized Difference Vegetation Index (NDVI) data from Advanced Very High-Resolution Radiometer raster images using QGIS. The opportunity he has provided is extremely valuable to me. I would like to thank my family, especially my mother, Mrs Victoria Omowunmi Afolabi, for always supporting me. I appreciate Dr L.N Ofodile of Yaba College of Technology and my friends for their support.

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List of Abbreviations

ATF – Anti-Deforestation Task Force

AVHRR*:* The Advanced Very-High-Resolution Radiometer

CBFM: Community-Based Forest Management

CPRN – Cross River National Park

CRS - Cross River State

DFID - The UK Department for International Development

FCPF: Forest Carbon Partnership Facility

FGN - Federal Government of Nigeria

GHG: Greenhouse gas emission

JMF: Joint Forest Management

LGA - Local Government Area

NGO: Non-Governmental Organizations

NDVI: Normalized Difference Vegetation Index

NOAA: National Oceanic and Atmospheric Administration

NTFP: Non-Timber Forest Products

ACF: Autocorrelation Function

PACF: partial autocorrelation function

PES: Payment for Ecosystem Services

PFM: Participatory Forest Management

REDD+: Conserving and Enhancing Forest Carbon Stocks and Sustainably Managing Forests

SL: Sustainable Livelihood

UN: United Nations

UNDP: United Nations Development Programme

UNEP: United Nations Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

UN-REDD: The United Nations Collaborative Programme on Reducing Emissions from Deforestation and forest Degradation

WCS: Wildlife Conservation Society

Study Overview

Chapter 1 introduces the research rationale and data source. It outlines the research question, hypothesis, aims and objectives. The section also provides an overview of the study's conceptual framework.

Chapter 2 focused on the literature review. It briefly examined previous studies on climate change and forests, the conservation initiatives before REDD+ as well as the challenges associated with them. The role of remote sensing in forest monitoring and management was also highlighted.

Chapter 3 provides information on REDD+, its benefit-sharing mechanism, impact evaluation, outcome, and implementation challenges. The participation of forest communities in REDD+, deforestation drivers and the ecological value of the Cross River State forest reserves were also discussed. Furthermore, the chapter describes the study area, data source, research design and method used for the study.

Chapter 4 presents the quantitative analysis and data interpretation of vegetation cover change in CRS using NOAA AVHRR time-series data.

Chapter 5 presents the survey result and discusses the face-to-face key informant interview. The REDD+ benefit was also presented. The study considered access to land resources, infrastructure, loans, networking, and information sharing by social groups as a tool to obtain maximum results in forest conservation. The section also provides insight into the socio-economic activities, climate change awareness and respondents' satisfaction with the government’s effort to conserve the CRS forests through the REDD+ program.

Chapter 6 discusses the quantitative and qualitative results. Based on the economic activity of the study area, it offers recommendations. Research limitations and suggestions for future research were outlined.

CHAPTER 1

This chapter introduces the rationale, the conceptual framework, as well as the objectives and aim of the study.

1. Introduction

Tropical forests play a significant role in supplying vital ecosystem services such as biodiversity conservation, water management and carbon sequestration (Fayle et al., 2015). However, global forests are degrading at an alarming rate. Anthropogenic activities such as agriculture, timber exploitation, mining, urbanization, road building, industry development and other land-use change have been identified as the major cause of forest loss and degradation (Kusimi, 2008; Kyere-Boateng & Marek, 2021, Munsi et al., 2012). This has led to biodiversity loss and disruption of ecosystem services. It is also contributing to climate change while climate change, on the other hand, has become a global threat and negatively impacts the ecosystem (Strassburg et al., 2014). The United Nations Framework Convention on Climate Change (UNFCCC) is striving to stabilise the greenhouse gas in the atmosphere to a tolerable level. As a result, the “Reducing Emissions from Deforestation and Forest Degradation, conserving and enhancing forest carbon stocks” (REDD+) initiative was introduced as one of the potential solutions. A major feature of the initiative is that it provides incentives to developing countries to contribute to climate change mitigation through activities that reduce carbon dioxide in the forestry and land use sector (Angelsen et al., 2012; Corbera & Adger et al., 2003; Schroeder, 2011).

Nigeria has lost 90% of its original forest to deforestation majorly due to agriculture and logging (Enuoh & Bisong, 2015; Inyang & Esohe, 2014). Nigeria is Africa's largest oil-producing nation, but the poverty level remains high. Before the crude oil discovery in Nigeria in 1956, the major component of the economy was agricultural products such as cocoa, palm oil and rubber. For instance, in 1961, Nigeria traded 42% of the world's groundnut oil, 18% of the world's cocoa and 27% of the world's palm oil. However, the 1970s saw agriculture's attention shift to the crude oil economy which was soaring in price. Local crop production declined, and Nigeria became a net importer of food products resulting in higher food prices (Ebhodaghe et al., 2022; Kemi, 2016; Nwokoma et al., 2022; Okorie & Lin, 2022; Okotie, 2018; Oyejide 1986, p. 10-14; Ukpabi, 2009). Apart from being exhaustible, there has been a decline in oil prices since June 2014, which has implications for the economy that relies on such resources (Baffes et al 2015; Baumeister & Kilian, 2016; Uzonwanne, 2015). Research has suggested diversification from oil and gas to non-oil sectors such as agriculture and tourism (Ahmed, 2015; Basher, 2010; BolanleFabamise & Ogunjobi, 2022; Olayungbo & Olayemi, 2018).

After decades of indifference, Nigeria's Federal Government started reforming the agricultural sector to bring the country's economy back to sustainable agriculture. (Adelodun and Choi, 2018; Matemilola, 2017; Ukeje, 2004). As of 2013, the agricultural transformation agenda was established to ensure global food markets, reduce foreign food imports, eradicate hunger, and create jobs in the country. The importation of some agricultural products was banned as a measure of the government’s commitment. Despite this, not much has been accomplished in food production and food prices are still high (Nwankpa, 2017; Adesugba & Mavrotas, 2016; Onuka, 2017). Although food insecurity is a global issue, a lack of industrial processing of local produce, improved technologies, under-investment in infrastructure, and non-functional agricultural policy is harming Nigeria's food security (Ahungwa et al., 2014; Matemilola, 2017; Ukpabi, 2009). Meanwhile, Nigeria has dedicated part of the remaining tropical forest to REDD+ which has implications for rural dwellers especially farmers as their livelihood depends on forest resources.

The Cross River State presently holds the larger percentage of the remaining tropical forest in Nigeria. These forests are among the last habitats for Nigeria's rare and critically endangered wildlife of which some are on the red list of the International Union for Conservation of Nature (IUCN). Due to its potential, the CRS was selected as Nigeria's first REDD+ pilot state (Abua et al., 2013; Digun-Aweto & Van, 2020; Friant et al., 2019). In preparation for the REDD+ program, the CRS government banned timber logging in 2008. A similar restriction was also in place for the collection of non-timber forest products (NTFPs). As a result, some people lost their source of livelihood, leaving them in a state of frustration. This led to conflicts between the forest communities and the key stakeholders overseeing the REDD+ program (Asiyanbi, 2016; Krause et al., 2019; Nuesiri, 2016).

Forest communities rely on forest resources for their livelihood. Therefore. it is essential to maintain a balance between livelihood and protection of the remaining global forest for human survival (Romañach et al., 2018). This call for conservation strategies that will sustain the livelihood of forest communities while protecting nature (Ezebilo, 2012). In sub-Saharan Africa, many rural people are underprivileged and are prone to climate extremes. They may become very vulnerable and unable to adapt to negative changes in the environment. Thus, their capacity building is paramount and needs considering when implementing a conservation project (Bele et al., 2013). REDD+ is expected to improve ecological and social welfare and people's livelihoods wherever it is implemented. In fact, this became an integral part of its design (Poudyal et al., 2016). It may influence participation in forest management and conservation as noted by Fagariba et al. (2018).

Research suggests that the sustainable management and conservation of forest ecosystems require accurate information and data on forest trends, land covers and periodical changes (Adeyemi & Oyeleye, 2021; Hasan et al., 2019). The information is crucial for natural resource managers, conservationists, and policymakers to make vital decisions. Satellite data has demonstrated high potential in capturing, detecting, and mapping the changes in forest cover and provides cost-effective information. The Advanced Very High-Resolution Radiometer (AVHRR) has long data records of surface reflectance and vegetation indices (Ji & Brown, 2022). Hence, its application in vegetation study.

1.1. Project Motivation

To achieve sustainable carbon reductions under REDD+ and avoid worsening the lives of vulnerable people, scholars have argued that it is vital the program contribute to community development and livelihood. Promoting sustainable livelihoods involves enhancing local capabilities, assets (natural, physical, human, social, cultural, and financial capital) and political capital. It is evident from previous studies (Chhatre et al., 2012; Satyal et al., 2021; Mazur & Stakhanov, 2008; Yahyah, 2019) that the importance of investing in them cannot be overstated. The availability of these assets improves well-being and influences adaptation strategies. In other words, adaptive capacity depends on assets and other resources related to sustainable livelihood (Mekonen & Berlie, 2021). As part of the resilience-building process, adaptive capacity is one of the most important elements (Nyamwanza, 2012; Wright, et al., 2012). As a community's adaptive capacity increases, it becomes more resilient and capable to respond and recover from shocks. However, resilience is not pro-poor, rather it is a mechanism by which systems self-organise to deal more efficiently and effectively with a variety of problems that may arise, including those resulting from climate change. Resilience building can reduce damage to individual lives and livelihoods (Béné et al., 2014; Dodman et al., 2012; Klein et al., 2003).

Several strategies, techniques, and activities are involved in building a community's resilience and adaptation. Some of the activities include road construction, the building of water reservoirs, river embankments and cyclone shelters to prevent flooding as well as acquiring the necessary knowledge to deal with the situation. Moreover, investments in public healthcare, skill development, people participation, good governance and the inclusion and creation of livelihood options for marginalised people to raise the standard of living have been argued to increase ecosystem resilience. This can reduce vulnerability and lead to sustainable management of natural resources. In agriculture, for instance, a community can become resilient through the empowerment and development of sustainable farming practices, farm diversification, loan provision, soil conservation techniques, disaster early warning programs, the use of salt-tolerant crops and drought or flood-resistant seeds (Agrawal et al., 2008; Bahinipati & Patnaik, 2022; Cooper & Huff, 2018; Elmqvist et al., 2019; Gaworek-Michalczenia et al., 2022; Jarzebski et al., 2017; Kansuntisukmongkol, 2017; Tanner et al., 2009; Toyoda, 2021).

Drawing on climate change, adaptation and resilience literature, many African nations' economies depend on sectors vulnerable to climate extremes. Despite this, there is a lack of modern technology, infrastructures, and other resources in most vulnerable communities to protect themselves and their environment (Costello et al., 2009; Hardoy & Pandiella, 2009; Rahman, 2013). A review of selected literature by Below et al. (2010), Rival (2013), Enamul et al. (2022), as well as case studies by Macintosh et al. (2012, p.20-196) highlights some conservation and remediation initiatives on how local communities can benefit and build resilience to climate change. The discussion part of this study presents two case studies. However, it is important to note that the approach given in each case is not exhaustive and it depends on which amenity(s) are chosen to be emphasised in the project. In other words, each project is not all-encompassing

In Nigeria, the Federal Government is shifting its attention and reforming the agricultural sector to bring the country's economy back to sustainable agriculture (Tiri et al., 2014; Vermeulen et al., 2014). Nigeria's inflation and living costs have been on the rise for the past decade. There are reports of families struggling to meet their basic needs, especially in rural areas (Babalola et al., 2022; Makinde, 2014). In addition to this, the introduction of the REDD+ program in the CRS is having an undesirable effect on the forest community’s livelihood (Asiyanbi, 2016; Krause et al., 2019; Nuesiri, 2016). Studies have shown indications of climate change in

Nigeria and its impacts are more pronounced in rural areas (Akande et al., 2017; Ologeh et al., 2018; Onyeneke, 2019; Rose et al., 2014). The CRS forest communities' families may become more exposed and unable to cope without livelihood assets and other institutional support.

After a decade, investigating the contribution of the REDD+ program to the socio-economic livelihood of the forest communities in the Cross River State, Nigeria, is paramount not only for the locals but forest conservation. The outcome of the study may provide information on what the community has gained to support their livelihood (based on the five livelihood capitals) to reduce deforestation and may prevent vulnerability to extreme events. In addition to this, identifying local people's preferences before conservation projects is vital to developing better plans as noted by Ezebilo (2012). By so doing, policymakers can make more acceptable decisions about nature conservation projects in a way that is more acceptable to the forest communities and the larger populace. Thus, the scope of this study extends to examine the livelihood preference of the CRS REDD+ communities. However, it is worth emphasizing that this is not a vulnerability or resilience assessment study, but rather infers passively to the existence of structures the locals would need to cope in this climate change era. The study focuses on REED+ benefit, capacity-building preference and forest cover change in the Cross River State, Nigeria.

Millions of hectares of tropical rainforests are degraded annually (Mayaux et al., 2005). Meanwhile, many species are endemic to primary tropical forests. Concerns have been raised among the academic community about the loss of these ecosystems. Forest cover change analysis may provide useful information to track conservation progress and land use change. It is also essential for conservation planning in high biodiversity protected areas vulnerable to degradation (Cimini et al., 2013; Falcucci et al., 2007; Morales-Hidalgo et al., 2015). Moreover, studying the rates of forest cover change can provide information on variations in forest gain or loss and the major drivers responsible for the change. Although, this may require a combination of biophysical and socioeconomic variables (Hansen et al., 2013; Leimgruber et al., 2005; Loran et al., 2017). Therefore, remote sensing was employed to provide quantitative information on the state of the Cross River State forests after ten years of REDD+ implementation. Recent studies on REDD+ in Cross River State, Nigeria, have focused on REDD+ implementation, participation, corruption and monitoring, reporting, and verification (see Amuyou et al., 2021; Asiyanbi, 2016; Isyaku, 2021; Ogbodo & Okeke, 2022). On the contrary, this study

- Assessed the CRS forest cover change using Normalized Difference Vegetation Index data to provide quantitative insight into the impact of the REDD+ program on the CRS pilot forests.
- Investigated the benefits of the REDD+ program and how it has improved livelihoods
- Examined the type of livelihood capacity-building the CRS forest communities would appreciate receiving to support forest conservation.
- Identify the challenges that the forest guards face in managing the CRS forest.

The use of qualitative and quantitative techniques to evaluate REDD impacts has been suggested in the literature to give a robust evaluation, especially where there is limited data (Mattsson et al., 2012; Duchelle et al., 2018). Hence, a mixed-method approach involving interviews, questionnaires, and remote sensing data was adopted in this study. The quantitative data were extracted from the annual daily 1km Normalized Difference Vegetation Index (NDVI) of the Advanced Very High-Resolution Radiometer (AVHRR) Version 5. The study was divided into two parts (i) an investigation of the CRS forest cover change using NDVI data and (ii) an assessment of the co-benefit of the REDD+ program on livelihood and the forest community's skill\training preference using qualitative data.

1.2. Research question

Has REDD+ improved the forest cover in Cross River State, Nigeria, and what benefits have the forest communities received to support their livelihood?

Sub-research questions

- How have the CRS forest communities benefited from REDD+ to improve their livelihood?
- What type of capacity building have and would the forest communities like to receive?
- Has forest cover increased or decreased since the inception of the REED+ program in the CRS?
- In what capacity are the forest communities participating in the REED+ project in CRS?
- Will forest modelling contribute to information needed by policymakers for effective decision-making in CRS forestry and Nigeria as a whole?

1.3. Research aim

This study seeks to know the economic activities of the CRS forest communities around the REDD+ sites and the kind of capacity-building they value. This may create the direction and support needed for forest conservation in Cross River State, Nigeria.

Research objectives

- To provide quantitative information on forest cover change using the National Oceanic and Atmospheric Administration (NOAA) AVHRR NDVI.
- To investigate the benefits and types of the capacity building provided by the REDD+ program
- To identify the forest community's skill\training preferences.

Specific objectives

- To obtain information from the forest communities about the REDD+ program's benefits through questionnaires and interviews.
- To collect quantitative data on forest cover change by extracting NDVI data from the NOAA AVHRR raster images using the Quantum Geographic Information System software and analyze it using a parametric t-test, autoregressive integrated moving average (ARIMA) model and Ordinary Least Squares regression

1.4. Research Hypothesis

H_0: The REDD+ program does not improve the CRS forest cover.
H_1: The REDD + program improved the CRS forest cover.

1.5. Conceptual Framework: The Sustainable Livelihoods Framework

The term sustainable livelihood (SL) refers to a development that is ecologically, institutionally, socially, and economically sustainable (Ashley & Hussein, 2000, p. 14). The SL concept has to do with the objectives, scope, and priorities for rural development to eliminate poverty. In other words, it is a people-centred approach that deals with poverty and well-being. The central notion is that individuals, households, or communities own and depend on different assets to accomplish diverse activities (Baumann, 2000; Majale, 2001; Norton & Foster, 2001). Therefore, the SL approach seeks to understand the lives of underprivileged people and how to improve their livelihood by building on the assets that they possess. Thus, the areas where livelihood interventions are needed are identified and enhanced to maintain people’s well-being under changing conditions (Baumann, 2000; Norton & Foster, 2001). Illiteracy, lack of social services, and a state of vulnerability are also taken into consideration (Krantz, 2001).

A sustainable livelihood contributes to the net benefit of both the current and the future livelihoods while not undermining the natural resource base. It maintains and enhances its assets, capabilities, and activities to sustain the ecosystem. Furthermore, a livelihood is sustainable when it can cope with and recover from the stress and shocks of extreme events (Ashley & Hussein, 2000; Chambers & Conway, 1992; Majale, 2001; Serrat, 2017). The sustainable livelihood framework recognises five major types of assets (capital). These are natural, human, social, physical, and financial capital (Chambers & Conway, 1992; Mohammadi et al., 2021; Quandt, 2018). Neupane & Shrestha (2012) maintain that these capitals are more than just a means of building livelihood, it is the basis for the ability to act and survive. According to Chambers & Conway (1992), a household may achieve sustainable livelihood security through land ownership, livestock, rights to grazing land, employment, diversification on a farm and small-scale economic synergy.

The potential outcome of SL may result in increased income, vulnerability reduction, improved food security and sustainable use of natural resources (Nguyen & Leisz, 2021; Serrat, 2017). Vulnerability in sustainable livelihood is how prone people are to adverse events and how equipped they are to respond to or cope with the issues. For instance, many areas in developing countries receive unpredictable rainfall, have limited resources, and face multiple risks. Therefore, they may become vulnerable to extreme events and other environmental shocks such as drought and flood. (Bogale, 2012; Deressa et al., 2008; Awotide et al., 2015). Pandey et al. (2017) explain that poverty, people’s marginalisation, and unsustainable use of resources may lead to vulnerability. The SL's operational framework also employs both participatory and policy tools (Majale, 2001). Various actors such as local government, municipal authorities and local communities are brought together in decision-making, policy formulation, and implementation (ibid). It is, however, important to note that the process and institutions through which policies are implemented are important to every livelihood aspect because they provide incentives that motivate people to make better choices. They can also grant or deny access to assets (Serrat, 2017).

Atela et al. (2015) explain that REDD+ directly relies on natural assets (e.g. land and forest) to achieve emission reduction targets. Meanwhile, households and communities use the goods and services provided by nature for their existence. Therefore, understanding local livelihood and assets are necessary to attain REDD+ implementation. Their concerns and voices must be heard (Atela et al., 2015; Resosudarmo et al., 2012). Studies have demonstrated the relationship between REDD+ benefits and sustainable livelihoods. Many viewed sustainable livelihood as the co-benefit of REDD+ (Peras et al., 2016). The REDD+ initiative is aligned with the United Nations Sustainable Development Goals and engrained in integrated conservation and development projects (Collins et al., 2022; Smith et al., 2019; Milbank et al., 2018).

To achieve carbon emission reduction objectives, REDD+ leverages the co-benefits aimed at livelihood improvement and biodiversity protection. Moreover, incentives such as capacity building. infrastructure, skill acquisition, employment, and knowledge transfer are particularly used when direct monetary benefits are uncertain or small. These are also the foundation of sustainable livelihood (Angelsen et al., 2012; Collins et al., 2022; Roe et al., 2013; Wong et al., 2019). The usefulness of a sustainable livelihood framework in assessing the impacts of REDD+ has been demonstrated. One of the reasons is that the approach considers social well-being, and income alongside environmental benefits (see Tacconi et al., 2013; Neupane & Shrestha, 2012; Bayrak et al., 2014). As mentioned earlier, the benefit-sharing of REDD+ appears strongly connected to the sustainable livelihood concept. Thus, the SL framework was utilized in this study as an analysis tool.

1.6. Definition of key terms

The definition of other key terms is captured in the following paragraphs. Baker & Florian (2014) and Boyle et al. (2016) define sustainable forest management as the use of forests and their resources in a way that does not damage the ecosystems but rather maintains biodiversity, socioeconomic, and ecological functions to meet the current and future needs. According to Nguyen & Leisz (2021), a livelihood is the capabilities, assets, and income that people possess to satisfy basic needs. This also includes shelter, clothing, cultural values, and social relationship. Barbier (2019) goes further to define natural capital as natural resources in the ecosystems that provide important goods and services and create economic wealth for human societies. This includes land, aquatic resources, forest products, wildlife, and biodiversity. Human capital on the hand comprised of education, information, knowledge, and skills that have economic value (Gillies, 2014; Marvel, 2013). Serrat (2017) and Xiong et al. (2021)

defined social capital as information sharing, social networks, connections, awareness creation, and relationships that encourage capacity building among groups of individuals. Examples of social capital include watershed and catchment management groups, irrigation, and water users' groups, forest management, and grazing land management groups (Amare, 2015). Israr & Khan (2010) refer to financial capital as savings, remittances, wages, and supplies of credit (loans) that households can access to support their livelihoods. Physical capital is defined as basic infrastructures such as roads, secure shelters and buildings, water supply, energy, and communications. It includes tools and technology for food production (Ros-Tonen et al., 2005).

Chambers & Conway (1992, p. 1-25) define capability as the ability to perform a specific function or what a person can do. Capacity may be enhanced through investment in education, training, and apprenticeships. According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability is the degree to which a system is susceptible and unable to cope with the adverse effects of climate change and extreme events (Soares et al., 2012). While a shock is an unexpected event or traumatic experience that causes a decline in well-being. Examples are droughts, floods, famine and epidemics of crops or animals (Gaiha & Imai, 2006). Resilience describes the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning. It also refers to the capacity to self-organise and adapts to stress and change (Gaworek-Michalczenia et al., 2022; Reyer et al., 2012).

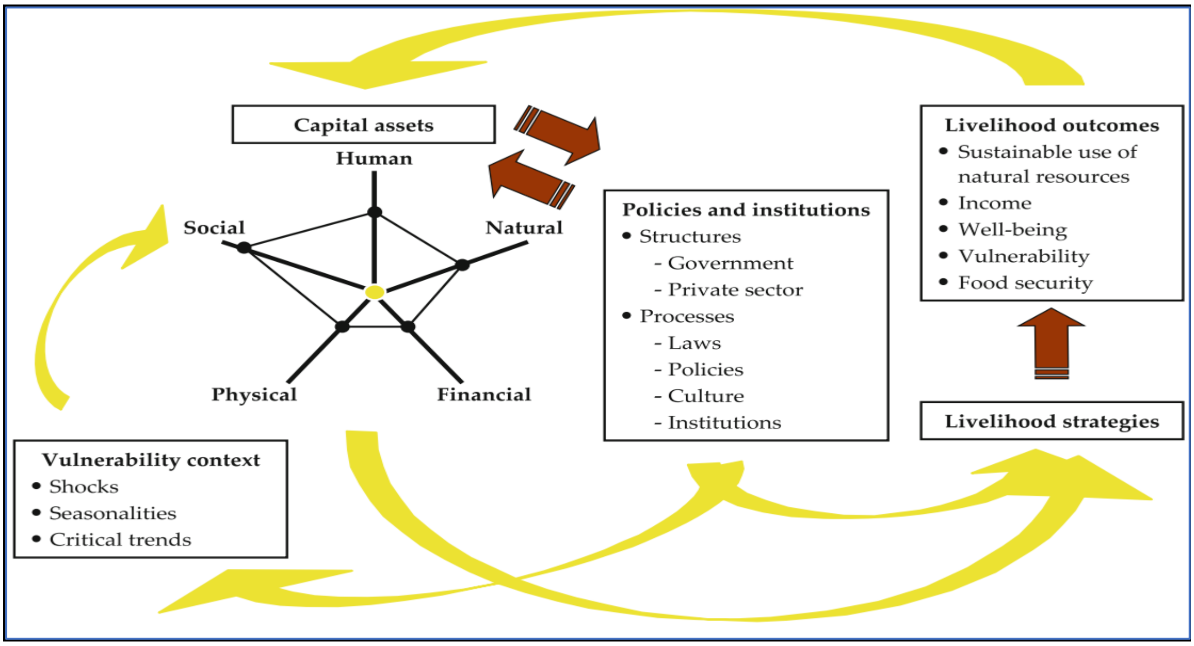

Figure 1: The Sustainable Livelihoods Framework showing the five capital assets (Serrat, 2017).

CHAPTER 2

2. Literature Review

2.1. Forest potential and climate change

A substantial body of knowledge on the cause of climate change shows that natural disasters like volcanoes and earthquakes are a source of greenhouse gas emissions (Hegerl et al., 2019; Xi-Liu & Qing-Xian, 2018). However, research has demonstrated that human anthropogenic activities such as deforestation, forest degradation, industrialization and transportation are the major factors of greenhouse gas (GHG) emissions causing climate change (Ainsworth et al., 2020; Hong et al., 2019; Hughes, 2011; Hegerl et al., 2019; Lestari, 2019; Meragiaw et al., 2021). Sagan et al. (1979) argue that the human role has been significant in global climate change during the last decades. Presently, similar changes are occurring as a result of human activities, causing increasing atmospheric temperature and global warming (Arora, 2019; Strassburg et al., 2014). For instance, a study on the contributions of natural systems and human activity to global greenhouse gas emissions by Xi-Liu & Qing-Xian (2018) evidence that human activity contributed more to global greenhouse gas emissions than natural processes, this accounted for 55.46% of total global GHG emissions as of the time of the study.

The earth's natural vegetation is constantly changing. Where the change is defined as an alteration in the surface components of the vegetation cover or as a spectral or spatial movement of a vegetation entity over time (Coppin & Bauer, 1996; Nackaerts et al., 2005; Zoran, 2010). The change could be a response to natural events. In other words, forests and biomass can be affected or reduced over time due to natural disturbances (Schelhaas et al., 2003; Zhang et al., 2017). It can also be abrupt, such as wildfires and mass tree logging. As a result, the forest's potential benefits may be reduced (Brando et al., 2014; Ratajczak et al., 2018). Forests provide humans with several goods and essential ecosystem services locally and globally. Fuelwood, timber, non-timber forest products (NTFPs), food, medicines, biodiversity preservation, and water are a few examples (Brockerhoff et al., 2017; Foley et al., 2007;).

Research has demonstrated the ability of all types of forest including agroforestry and regenerated forests to sequester significant amounts of global carbon dioxide (see Alongi, 2012; Bernal et al., 2018; Luyssaert et al., 2008; Nowak & Crane, 2002; Smith et al., 2014). Among such studies is Ray & Jana (2017) who report that the Indian Sundarbans mangrove forest absorbed 0.64% of coal-fired power station emissions between the year 2011 and 2012.

Despite all these benefits, the loss of biodiversity, plant and animal species, and other forest resources continues at an alarming rate worldwide (McCauley et al., 2013; Becklineet al., 2022; Reza & Hasan, 2019; UNEP, 2020). The unprecedented forest loss is also affecting the people who depend on them for their livelihoods (McCauley et al., 2013; Ezebilo, 2012).

Over the decades, there has been a growing concern about the mismanagement and over-exploitation of forest resources (Kyere-Boateng & Marek, 2021; Kimengsi et al., 2022). According to Angelsen et al. (2012), approximately 30% of the earth's land area is covered by forests. Likewise, Keenan et al. (2015) documented that global forest area decreased by 3%, from 4128 million hectares to 3999 million hectares between 1990 and 2015. The cause of deforestation and degradation differs from place to place. According to studies, this is largely determined by human factors such as agriculture, industrialization, environmental knowledge, education (Fagariba et al., 2018), wealth creation, and location (Timko et al., 2010). For example, Bi et al. (2020) research on the response of grassland productivity to climate change and anthropogenic activities in arid regions of central Asia reveals that grassland primary productivity has diminished significantly in the study area due to human activities.

Similarly, a study by Liu et al. (2001) on ecological degradation of protected areas for endangered giant pandas in Wolong Nature Reserve, China, found that habitat loss and fragmentation increased due to human activities. A decline in forest water availability as a result of agricultural water demand was also reported in an article by Lim et al. (2019). Forest conversion is primarily driven by large-scale agribusiness companies and smallholder farmers, especially in the tropics. However, the reality is that agriculture provides the fundamental source of income for rural households to meet their needs. In other words, rural farmers heavily depend on forest resources for their livelihood (Appiah et al., 2009; Luna et al., 2020). Due to this, forest conservation often conflicts with local demands for agricultural land (Ezebilo, 2012) and negatively impacts the income from forest products (Djurfeldt et al., 2017).

Therefore, the alignment of conservation goals with local livelihoods and socioeconomic factors has become increasingly challenging (Giliba et al., 2011; Angelsen et al., 2012). Kelbessa & De Stoop (2007) argue that to manage forests effectively and sustainably, local people need multiple sources of income. Moreover, smallholder farmers are needy and have less land. A lack of income and technology could further impoverish them. Studies have shown that REDD+ may not contribute to the socioeconomic development of a country in a significant way. Therefore, developing countries may have difficulty giving up agricultural activity for forest protection. These actors will likely seek huge compensation from REDD+ for the losses they will experience if forests are not converted into agricultural lands, especially with a growing demand for their products. Compensating agricultural producers does not look feasible, and even if it is, they may feel economically dependent on REDD+ since they would lose land-based income. Howbeit, whether such payments are substantial enough to transform rural economies or generate activities that will lower carbon emissions is a vital issue that matters a lot. It determines the future and outcome of REDD+ (Kibii, 2022; Da-Silva et al., 2022; Den-Besten et al., 2019; Pacheco et al., 2010).

Having highlighted that, forest and climate change issues are intertwined. In addition to human impact on forests, research has shown that climate change is also negatively affecting forests. Hartmann et al. (2022) document events characterized by a sudden and unexpected increase in tree mortality in a study of climate change risks to global forest health. The problem was caused by heat and drought in ecosystems that were previously considered tolerant and not at risk. These authors posit that events such as this demonstrate the potential for forest degradation with unexpected consequences resulting from climate change (ibid). Likewise, global warming is increasing forest fire regimes and severity (Huang et al., 2021; Mansoor et al., 2022).

2.2. Forest management, conservation problems and solutions before the REDD+

Historically, tropical forests have been modified, transformed, and impacted by humans (Roberts et al., 2017). Forests are still facing enormous pressure from population growth and various human activities. Although the underlying causes of deforestation vary among countries, they are similar (Deka et al., 2022; Scerri et al., 2022). Forest conservation and development initiatives have been evolving over the years to improve the management of forests, wildlife and biodiversity as well as reduce forest degradation. Around the world, the establishment of national parks and protected areas has increased. While this provided some solutions, it has not been very effective (Locke & Dearden, 2005; Eagles & McCool, 2002; Kajembe & Luoga, 2006; Massiri et al., 2020).

Before REDD+ was established, forest communities and conservationists developed various management approaches to nurture forests and their resources. They set by-laws and self-regulations regarding access to forest products (Zahabu, 2006). Examples of strategies used in forest conservation include payment for forest ecosystem services (PFES)**,** participatory forest management (PFM) joint forest management (JFM), community-based forestry management

(CBFM), and social forestry (Bayrak & Marafa, 2020; Nath et al., 2020; Zahabu, 2006). The PFM prevents marginalisation and ensures the participation of indigenous peoples in the decision-making, negotiation, implementation, and management of conservation projects. In this method, villagers acquire formal and legal rights to use and profit from forest resources (Nath et al., 2020; Veerakumaraan & Mekuria, 2007). According to Tadesse et al. (2016) and Vyamana (2009), PFM has the potential to improve forest conditions. This support Kairu et al. (2021) who argued that PFM was beneficial in Gazi Bay, Kenya because it improved the management of mangrove forests. Literature advances that many governments in sub-Saharan Africa are implementing PFM and partnering with local communities (Duguma et al., 2018; Mazur & Stakhanov, 2008). Nevertheless, PFM is not pro-poor (Vyamana, 2009) and it may not suffice to conserve forests (Siraj et al., 2018).

Joint Forest Management (JFM) is a form of participatory forest management that includes government-owned forest reserves both at the national and local levels. Therefore, land ownership remains with the state government. The forest management responsibility and revenue are shared between the state and the community through a formal agreement. Local communities are responsible for forest activities such as patrolling, boundary clearing, and firefighting. Consequently, they are granted the right to access some forest products and services. The off-take process, however, follows an agreed management plan for ensuring that the resources are sustainably managed (Deb, 2020; Blomley et al., 2011; Blomley & Ramadhani, 2006). In contrast to other forms of forest management, CBFM is undertaken on lands registered as village property and is managed by the village council. Thus, local communities are recognized as the rights holders and duty-bearers of the forests. They are solely responsible for all the activities involved in managing the forest. According to the literature, JFM and CBFM approach improved forest management (Lokina & Banga, 2018; Iddi, 2014; Blomley et al., 2011; Gbedomon et al., 2016; Mwakalobo et al., 2011).

Despite best efforts, forest conservation initiatives face challenges that prevent them from accomplishing their long and short-term goals. Due to the limitations, few solutions have been achieved (Miller-Rushing et al., 2017). Some of the problems were lack of funds (Bonine et al., 2003), unresolved property rights, and illegal logging (Vandergeest, 1996). Furthermore, local people engage in conflict and express anger and hostility towards conservation efforts, especially when access to forest resources is denied (Wild & Mutebi, 1996; McElwee, 2004). Some of the strategies that have been employed to resolve these issues were the participatory method, and the distribution of alternative to fuel wood material such as smokeless cookstoves to households that used wood for cooking (Molnar, 1987).

According to Sunderlin et al. (2014, p. 1-12) and Pacheco et al. (2010), many conservation programs in the 1980s and 1990s also engaged in incentives, improvement of forest and non-forest-based livelihoods, restricted or controlled access to forests resources and environmental education. For instance, forest authorities in Uganda allowed locals to obtain certain resources under their guidance in the Bwindi Impenetrable Forest and Mgahinga Gorilla National Parks project. Forest patrols were also employed to track unapproved activities (Wild & Mutebi, 1996). Research suggests that a successful conservation initiative relies on grassroots involvement, dedication and participation in the planning and implementation of projects. Furthermore, it is essential to structure conservation efforts in a way that is both economically and socially beneficial to the local people (Adams & Hulme, 2001; Irawan et al., 2019; Zahabu, 2006; Skutsch et al., 2009).

2.3. The role of remote sensing in forest management

The sustainable management of forest ecosystems requires accurate information and up-to-date data on forest trends, land covers and periodical changes. This information is crucial for natural resource managers, scientists, policymakers, and researchers to assess carbon budgets, predict fire behaviour and understand biodiversity among others. Qualitative and quantitative data can be combined to assess the outcome of such projects or programs (Adeyemi & Oyeleye, 2021; Harris et al., 2021; Hasan et al., 2019; Vogelmann et al., 2012). Understanding vegetation trends and variability over the national and global regions has largely been accomplished by applying earth observation data, especially the data collected via satellite sensors (Ji & Brown, 2022). According to the body of knowledge, remote sensing technology and high-resolution satellite data are critical in understanding and predicting future forest reactions to disturbances (Hartmann et al., 2022). This is due to the cost-effective information and high accuracy of the satellite to capture, detect and map the changes in forest cover (Nguyen et al., 2022; Selvaraj et al., 2020; Al-Ali et al., 2020; Coppin & Bauer, 1996).

For example, the Landsat programs and their applications have become vital tools worldwide for understanding scientific issues related to changes in the earth's natural resources and land use (Pahlevan, 2014). Remote sensing is useful in climate change study, agriculture, land mapping and water assessments (Loveland & Dwyer, 2012). To illustrate, an area of agricultural land affected by diseases or water deficiency can be easily differentiated from other areas by comparing archived images of remote sensing data (Nowatzki et al., 2004). Previous research (Al-Bakri & Taylor, 2003; Ehrlich et al., 1994; Fensholt et al., 2009; Lambin et al., 1993) have examined the usefulness of satellite systems and sensors with high temporal frequency such as the Advanced Very High-Resolution Radiometer (AVHRR). The NOAA AVHRR NDVI time-series data have been used in many sectors. Besides providing biophysical vegetation metrics, it can be used to monitor vegetation changes, land cover changes and crop conditions (Domenikiotis et al., 2003; Esquerdo et al., 2011; Zhengxing et al., 2003). The following two paragraphs present a few examples of AVHHRR NDVI's use.

To verify the value of AVHRR-NDVI, Brown et al. (2006) examined the consistency of the Normalized Difference Vegetation Index (NDVI) records derived from different satellite sensors. The AVHRR, SPOT-Vegetation, SeaWiFS, Moderate Resolution Imaging Spectroradiometer, and Landsat ETM+ satellite sensors were used in the study. The results indicate that their variances are similar and suggest that it may not be necessary to choose between the longer time series of AVHRR and the higher quality of the modern sensors. However, AVHRR NDVI records provide a unique historical perspective on vegetation activity that is crucial to global change research (Guay et al., 2014; Guo et al., 2018). Munsi et al. (2012) research on Spatio-temporal change patterns of forest cover in Himalayan foothills (India), indicates that geospatial techniques can be used to understand Spatio-temporal forest cover change and construct future scenarios.

AVHRR NDVI data has been demonstrated to be beneficial for monitoring and simulating temperate ecosystems. It can be used to study phenological cycles and stages of plants as shown in Duchemin et al. (1999) study of deciduous forest ecosystems in France. The study found that oak phenological cycles differed among the forests examined, as well as the climatic features of the study areas. As Panday & Ghimire (2012) illustrates, AVHRR NDVI data can be used to detect greening trends in shrubland, grassland, and cropland as well as the season in which they occurred. The study also provided insight into the deforestation trends in the Hindu Kush-Himalayan region of central Asia. Thiam (2003) maintains that a multitemporal 1 km AVHRR NDVI was effective in detecting a decline in biomass production due to rainfall deficits and uncontrolled exploitation of local natural resources in a study conducted in southern Mauritania. A similar study by Maselli (2004) also proved that NDVI derived from NOAA AVHRR data was useful.

The working principle of satellite sensors depends on energy detection. They measure and record information about the energy reflected and the changes occurring on objects as they orbit the earth daily. Following their physical characteristics, both biotic and abiotic materials such as soil, plants, and oceans interact with electromagnetic radiation via absorption and transmission. Electromagnetic radiation is primarily produced by the sun which is composed of infrared, ultraviolet, and visible light. Vegetation remote sensing is performed using passive sensors that measure the electromagnetic wave reflectance of plants. When plants are stressed, their ability to grow well and produce chlorophyll, the primary pigment responsible for photosynthesis is hindered. Meanwhile, plant pigmentation determines the visible portion of the spectrum in green vegetation.

Healthy vegetation absorbs most of the visible light that encounters it and reflects more of the near-infrared light. In contrast, when it is stressed or sparse, it reflects more visible light and less near-infrared light. The satellite sensors detect and store the radiated information emitted by the plant. The changes are measured by vegetation indices which are useful tools for monitoring vegetation greenness. Vegetation indices “VI” are numerical indicators that use the visible and near-infrared bands of the electromagnetic spectrum to analyse the remote sensing measurements and assess whether the target being observed contains green vegetation. The values of VI can vary according to sensors, compositing algorithms, and plant types. One of the most used VI is the Normalized Difference Vegetative Index (Gao et al., 2020; Hüsler et al., 2014; Glenn et al., 2008; Govender et al., 2007; Knipling, 1970; Running et al., 2004; Tedesco, 2015; Xiao et al., 2019; Xue & Su, 2017; Zeng et al., 2022).

Apart from remote sensing, some other methods described by researchers in forest monitoring, disturbance or change detection are participatory forest monitoring, the Point Centred Quarter method and the forest inventory method. A participatory forest monitoring method consists of on-site visits by biologists and trained local people to observe, report and collect data about any changes in vegetation cover in conserved areas. In addition, local forest guards are also used. They patrol the forests regularly to spot changes in land use, illegal logging, and poaching. The advantage of this method is that human interference can be easily detected. Land cover changes cannot be accurately measured with this method, and it is less scientific. Other limitations are conflicts, bias, local residents’ low education, and misuse of power (Krause & Zambonino, 2013; Garcia & Lescuyer, 2008; Holck, 2008).

The Point Centred Quarter method is another method used to measure canopy cover, density, forest disturbance, and distribution of tree species (Wilder et al., 1998). Parameters such as the height and diameter of trees can be estimated using this technique. Quantitative data are generated based on the mean distance between plants in a quadrant of a random sampling point which is the origin of coordinates. In addition to overestimating tree density, statistical uncertainty, bias, and lack of uniformity can result from a sample measurement (Dahdouh-Guebas & Koedam, 2006; Holck, 2008; Khan et al., 2016; Zhu et al., 2015). Stuart-Hill (1995) maintain that the method is time-consuming and complicated mathematically.

To determine the state of forests, research has highlighted the importance of forest inventory methods. Forest inventories provide ground-based data regarding biomass, wood harvest forecasting, growth monitoring, CO_2 fluxes, land-use change, and forest disturbance. Traditionally, forest inventory involves various levels of field sampling to collect information on Spatio-temporal characteristics of forests such as growth, height, and the volume of standing and fallen trees among others. Over the past few years, it has expanded to include assessments of biodiversity, wildlife, watershed management, and forest use on a regional, country, and global level. The variables are calculated through statistical techniques. It has been argued that the information collected using this method is less diverse, time-consuming, labour-intensive, inefficient and subject to error (Böhl & Brändli, 2007; Borecki et al., 2015; Nabuurs et al., 2010; Latifi et al., 2015; Pan et al., 2004). In some studies (Hyyppä et al., 2008; Ko et al., 2021; Latifi et al., 2015; Mengesha et al., 2015), forest inventories have been combined with LiDAR (light detection and ranging), airborne laser scanners, and terrestrial laser scanners. LiDAR is applicable in measuring biomass loss, which is crucial for forest emissions data and can capture 3-D forest structural information (Gao et al., 2020).

Remote sensing is increasingly being used in many countries around the world to monitor the state of the forests including reporting greenhouse gas emissions and carbon sinks which are core to REDD+ as shown in the literature (Goetz et al., 2015; Latifi et al., 2015; Mitchell et al., 2017; Souza et al., 2013). The use of satellite remote sensing technology offers several advantages, including the ability to study vegetation systems at a much larger scale and the possibility to collect substantial numbers of samples at a relatively fast rate for ecological and climate science research. It is cost-effective and eliminates human interference with data (Achard & Hansen, 2012, p. 1-10; Jones et al., 2010, p. 1; Ozesmi & Bauer, 2002; Shirazy 2021). It also reduces uncertainties (Houghton et al., 2009).

Further, remote sensing provides consistent data that can be used to detect changes in forest cover over time by comparing early measurements with subsequent measurements (Banskota et al., 2014; Potapov et al., 2014). Nonetheless, remote sensing technology does have certain drawbacks. A few examples include cloud and aerosol contamination (Xiao et a., 2017), snow (Rechid et al., 2009; Delbart et al., 2006), missing values (Sajadi et al., 2021) and spectral similarity of different land cover classes (Krause & Zambonino, 2013). While remote sensing data can provide a wide range of advantages, McRoberts & Tomppo (2007) argue that it may not be all-embracing to replace ground data. This is because the information provided may not refer to a specific cause of forest degradation or disturbance most time. Thus Goetz et al. (2015) stressed the importance of coalescing field-based study with remote sensing, for instance, in REDD+ evaluation, monitoring, reporting and verification study for the best outcome.

It is worth highlighting that prior to REDD+ in Nigeria, some forest communities in the CRS had been supported in the past by the UK Department for International Development (DFID) and Living Earth NGOs programs, as noted by Geraldine & Emmanuel (2016). Nevertheless, some alternative livelihood programs introduced in CRS forest communities have failed to achieve their objectives, Nuesiri (2006) contends that technical solutions alone cannot alleviate poverty. It is crucial to understand the socioeconomic dynamics of the local area. According to Krantz (2001), poverty alleviation in rural areas can be achieved by considering what matters to people. In other words, it involves understanding the different groups of people and working with them in a manner that aligns with their livelihood economically and socially.

Literature and official reports on REDD+ in Nigeria showed that capacity-building training was carried out in the CRS local communities. The skilled areas were global positioning systems, geographic information systems (Asiyanbi et al., 2017), forest monitoring and participatory mapping to produce land-use plans (Oyebo et al., 2010) and Measurement, Reporting, and Verification (Olaniyan et al., 2021) among others. This implies that previous training under the REDD+ focused on capacity building for forest monitoring, conservation, and management. Although the training and skills are essential in achieving an effective outcome in the REDD+ program, they might not specifically address livelihood issues. This study set out to know the impact of REDD+ on the CRS forest, the skill preference of the forest communities and the benefit they have received to improve their livelihood.

CHAPTER 3

This chapter gave an overview of the population and economic profile in the CRS. It presents issues related to the logging ban and the underlying cause of deforestation in Nigeria. The REDD+ program was described along with the ecological values of CRS forests. This chapter also provided an overview of the NOAA AVHRR NDVI and described the method adopted for the study.

3. Description of the study area

The study area for this research is Cross River, Nigeria. There are six geopolitical zones in Nigeria: The South-West, the South-South, the South-North, the North Central, the North-East, and the North-West. The country has 92.3 million hectares of land, 13% of which is forested. In Nigeria, the main forest types are mangrove forests in the Niger Delta and along the southern coastline, rainforests, montane forests, woodlands, and derived savannah in the north (Maukonen et al., 2017; Shiru et al., 2020). The Cross River State (CRS) is one of Nigeria's 36 States. It is located in the South-South geopolitical zone of Nigeria. CRS occupies an area of 20,156 square kilometres with latitudes 4015N and 7000'N and 7015'E and 9030'E. The state shares borders with Benue State in the north, Ebonyi and the Abia States in the west, Akwa Ibom State in the southwest, the Republic of Cameroon in the east, and the Atlantic Ocean in the south (Oyo-Ita et al., 2021; Enoh et al., 2020; Ebingha et al., 2019; Enuoh & Ogogo, 2018).

There are three senatorial districts in the CRS, Northern, Central, and Southern. CRS is made up of 18 Local Government Areas (LGAs) that are unevenly distributed among three senatorial districts of the CRS: these are the south (seven LGAs), central (six LGAs) and north (five LGAs) senatorial districts. The LGAs are further subdivided into wards which are made up of towns and villages. Moreover, every village is led by a village head (a traditional leader). The village heads and their respective clan heads comprise the council of chiefs in each ward (Oyo-Ita et al., 2021). The ecological zones of CRS include lowland rainforest, freshwater swamp forest, mangrove vegetation, coastal vegetation, and montane vegetation. Significant areas of CRS forest have been converted to farmlands and natural forests (Onojeghuo & Onojeghuo, 2015). In the CRS, the rainy season begins between April to October, followed by the dry season between November and March (Ogogo et al., 2013).

3.1. Population and economic profile of Cross River State

The CRS has approximately three million people. According to Ottong et al. (2010), the population of the CRS increased from 1.9 million (1.911.297) in 1991 to 2.9 million (2,888,966) in 2006. The population increased by 50% between the two census years. The population of Calabar, the state capital of CRS, increased from 285,065 in 1991 to 375,196 in 2006 (Eni and Ukpong, 2014). Nigerian censuses were last conducted in 2006. Therefore, it is estimated that the population of the state is now twice that of 2006 (ibid). Based on a constant growth rate of 3.0% and the rapid population growth in Nigeria, the CRS population is likely to exceed 5 million by 2025 (Ottong et al., 2010).

In CRS, agriculture and agro-based industry are the leading non-oil revenue-generating sectors. The percentage of employment in this sector was about 45%-80% of the state’s labour force and contributes 40% to the State’s GDP. Other occupations include tourism, construction sectors (Ayara et al., 2013; Eteng & Agbor, 2018) and timber logging (Fon et al., 2014). The CRS contributes significantly to the national economy by producing a large proportion of the country's main staples, such as yam, cassava, palm oil, and commercial cash crops as at the time of Abua et al. (2013) report. Nevertheless, the incidence of poverty has increased in Cross River State since 1980. The poverty rate was 10.2% in 1980, it rose to 41.9%. 1985. As of 1992, it was 45.5%, then rose to 66.9% in 1996. As of 2010, 52.9% of people lived in poverty (Ovat, 2015).

3.2. Forest Reserves in Cross River State

In Nigeria, the primary forest covers about three percent of the total forest area which remains relatively intact. Most of the forests are in the southeast of Nigeria (Enuoh & Ogogo, 2018). According to Ambe & Obeten (2020), during the colonial period, some tropical forests in Cross River State were designated as forest reserves. In accordance with this, thirteen forest reserves were established. Namely, the Cross River North Forest Reserve, Cross River South Forest Reserve, Agoi Forest Reserve, Ukpon Forest Reserve, Ekinta Forest Reserve, Uwet Odot Forest Reserve, Umon Forest Reserve, Lower Eniong Forest Reserve, Ikrigon Forest Reserve, Afi River Forest Reserve, Yache Forest Reserve, Gabu Forest Reserve, and Ikom Fuel Wood Plantation. The CRS forests share a common border with the forest of southern Cameroon and Cameroon’s Korup National Park. It lies between latitude 4˚28' and 6˚55' North of the Equator and longitude 7˚50' and 9˚28' East of the Greenwich meridian.

The CRS forests are primarily under the management of federal and state-protected areas. These forests are made up of forest reserves, community forests and forest concessions managed by private companies (Krause et al., 2019; Maukonen et al., 2017). These are gazetted forests managed for conservation and the production of forest resources have been significantly depleted and degraded over the years by the local communities for traditional farming practices and by timber loggers (Maukonen et al., 2017). In 1991, the Cross River National Park (CRNP) was established by the Federal Government of Nigeria (Maukonen et al., 2017).

Before the CRNP was created, the National Park Service (NPS) reorganized the remaining forests into four groups based on contiguousness. These are the Oban Group Forest Reserve, Okwangwo Forest Reserve, Boshi Forest Reserve, and Boshi extension Forest Reserve. They account for a total land area of 4320.12 square kilometres. Ite & Adams (1998) report that forest cover declined even after the establishment of CRNP in 1991. The study corroborates with Alu (2021) who also noted that between 1975 and 2020, the forest cover of the Oban division of the CRNP decreased by 1909 km which is an average of 42 km2 per year. Encroachment still occurs because of farming and population growth. Moreover, local communities continued to hunt for wildlife, fuelwood, and timber. A larger percentage of the CRS population lives in rural areas and depends on the forest for subsistence farming (Abua et al., 2013; Ambe & Obeten, 2020; Maukonen et al., 2017). The local comprises over 2,000 rural communities of CRS (Fon et al., 2014).

3.3. Forestry law, logging ban and conflict in CRS

In CRS, there are forestry laws, rules and regulations on the use and protection of forest products (Ajake & Anyandike, 2012; Enuoh & Bisong, 2015). An example of this is the Cross River State Forestry Commission (CRSFC) Law of 2010. It was set in place to preserve and manage the forest and wildlife resources sustainably in the CRS. The law also established eight (8) departments and units within the State Forestry Commission, including Carbon Credit Unit. Under this law, the engagement and collaboration of stakeholders such as civil society, the private sector government agencies, communities, and afforestation programmes are recognised to manage the CRS forests sustainably. The law also manages the compensation of the CRS forest communities by paying them royalties for the revenue generated from the sales of forest resources. However, the royalty stopped in 2008 due to the ban on timber logging in preparation for REDD+. Therefore, some of the provisions under the CRSFC law, for instance, land, resources use plan and management plan, have not been realised (CRS REDD+, 2017).

Ajake & Anyandike (2012) maintain that the enforcement of forest laws in CRS is mostly carried out by government forest workers who are not well equipped. This presents some difficult situations in their efforts to protect the forest. According to Asiyanbi (2016) and Krause et al. (2019), the logging ban in CRS affected the local communities' livelihoods by reducing their access to forest resources. A variety of enforcement measures, including equipment seizure, fines, confiscation of forest products, and even imprisonment of violators, were reported. There were allegations that the former Anti-Task Force (ATF) of the CRS was engaged in illegal timber dealings and corrupt activities. In transit or at the point of sale, the ATF apprehends loggers and confiscates timber. Afterwards, the timbers were auctioned off for revenue. Forest offenders were prosecuted and imprisoned or made to pay a huge amount of fine if found guilty, which was another revenue source. Permits were also claimed to have been issued to people collecting Non-Timber Forest Products (NTFPs).

Following the collection of the NTFPs, the ATF impounds them and requests further payment. Apparently, the locals had no choice but to pay to obtain another permit from the CRS Forestry Commission. Meanwhile, deforestation was supposed to be prevented and guarded against by the ATF. This was regarded as an act of corruption and an illegal timber economy that flourished. Reports indicated that this threatened the livelihoods of local communities and NTFPs collectors. They wrote several petitions to the governor of CRS, but to no avail. This resulted in illegal forest product extraction in the CRS and the ATF experienced a violent conflict with the locals (Asiyanbi, 2016; Nuesiri, 2016). In addition to this, Krause et al. (2019) noted that forest loggers often get unofficial permissions by paying some local people, particularly the chiefs, to cut trees and hunt in community forests and reserves. It is important to note that despite the disbandment of the ATF, the CRS remains under the logging ban. As reported by Onojeghuo et al. (2016), timber traders believe that the enforcement of the timber ban would negatively impact their business and only increase illegal logging activities across the CRS.

According to Asiyanbi (2016), the logging ban did result in increased deforestation rates, illegal logging, and forest clearing for agricultural purposes. Oyebo et al. (2010) mentioned that conflict also emanated in the forest areas because villagers from the local area were employed as park staff when Cross River National Park was created in 1991. Later, the workers were laid off, resulting in animosity. Similarly, the Okwangwo Division (OD) of the CRNP believes that the area belongs to them and that they should be compensated. Through restricted access to land for farming and forest products, they argue that the project negatively affected their livelihoods (Ezebilo, 2012). Furthermore, Andrew-Essien (2014) pointed out that conflict at the CRNP was associated with the park's location, objections from communities when access to forest resources was restricted and inadequate compensation from park management. These are indicators that may have threatened the communities and conservation goals. To achieve a positive conservation result, it is vital to acquire free, prior, and informed consent from indigenous communities on projects that affect their lives and livelihoods (Roe et al., 2013).

3.4. Causes of deforestation in Nigeria and the CRS

In Nigeria, logging and hunting are often driven by income generation (Krause et al., 2019). Nigeria's deforestation and forest degradation are caused by several factors. They are directly driven by agriculture, infrastructure development, crude oil exploitation, fuelwood production, and commercial logging. The indirect drivers are urbanization, population growth, property rights, and a lack of access to efficient agricultural technologies. The sustainable management of the CRS forests is further challenged by weak enforcement of forest laws and regulations, lack of public awareness, inadequate environmental education and insufficient legal backing for ecosystem restoration efforts (Ambe & Obeten, 2020; Enuoh & Bisong, 2015; Oyebo et al., 2010; Udumo et al., 2020; Maukonen et al., 2017). As a result of overexploitation by local people, wildlife and tree species have declined. In 1991, the CRS forest cover was 7,920 km2, it reduced to 6,102 km2 in 2008. The rate of deforestation has been estimated to be 2.2% annually (Abua et al., 2013). In other states of Nigeria, the deforestation factors are the same (Oyebo et al., 2010).

3.5. Methodology

3.5.1. Selection of study site and participants

This research was conducted using a mixed-method approach. Thus, it combined remote sensing data, interviews, and survey instruments to obtain information on the impact of the REDD+ program on the CRS forest, in Nigeria. The research was carried out in two REDD+ sites at Akamkpa and Boki local governments. A total of six forest communities around the sites were selected (three sites in each Local Government Area) using a purposive and snowball sampling technique. The project took place at the REDD+ sites in Boki and Akamkpa LGA of Cross River State, Nigeria. At the Ekuri–Iko Esai River forests REDD+ site, the Ekuri, Iko

Esai and Owai forest communities in the Akamkpa local government areas were selected. While at the Afi Mountain/Mbe Mountains REDD+ site, the Abo, Kanyang II and Buancho forest communities in Boki's local government were selected. These communities and the participants were purposely selected because of their proximity to the forests where REDD+ is located as the project may directly affect them. Furthermore, some of these communities have previously participated in REDD+ programs, workshops, and research projects (Krause et al., 2019). In addition, the UK Department for International Development (DFID) and Living Earth NGO have supported community forestry programs in these villages in the past (Geraldine & Emmanuel, 2016).

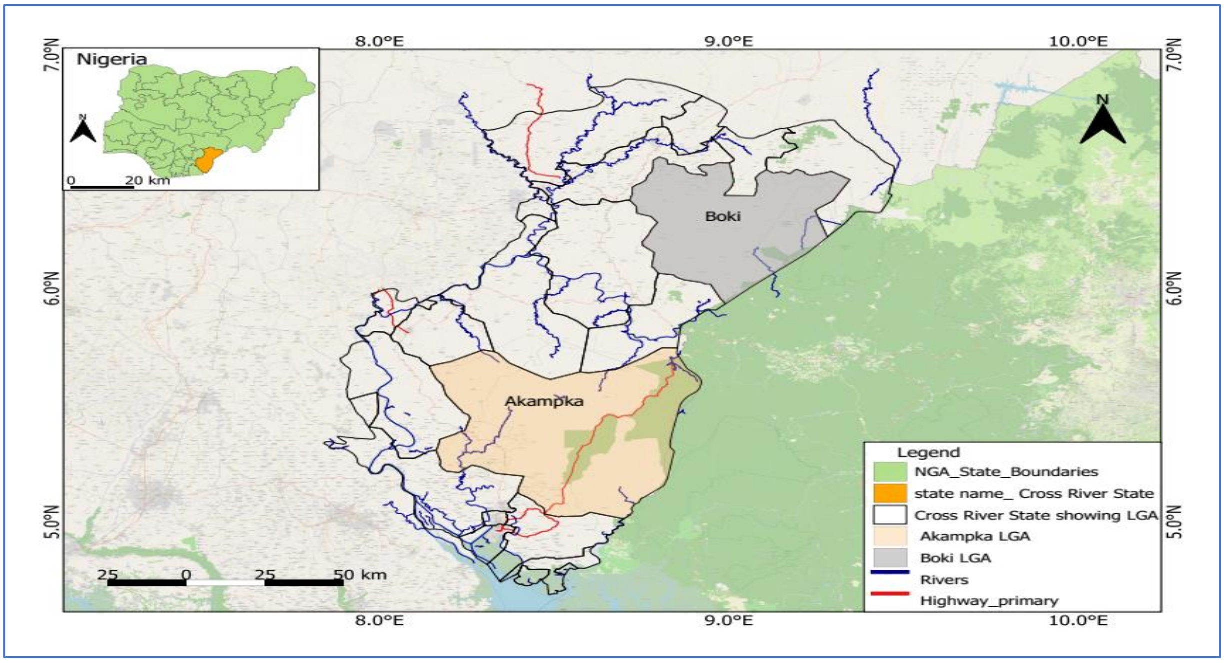

Figure 2. Map of Cross River State, Nigeria showing study locations (Basemap: OpenStreetMap, Licensed under the Open Database licence).

3.5.2. Survey instrument method

The local CRS forestry office was identified, and participants were contacted to participate in the research willingly. A structured questionnaire was administered to 160 villagers around the REDD+ sites to obtain information. The data were analysed using Statistical Package for Social Sciences (SPSS) by leveraging its in-built statistical techniques of frequency and percentages. The sustainable livelihood framework was employed to assess the benefit of the REDD+ program on the five livelihood capital assets. Additionally, data were collected through an interview that was conducted with eight key informants using open questions. The informants were purposely selected because they were directly involved in forest monitoring and patrol in the CRS. This comprises one community chief and seven forest officers\guards. A snowball sampling technique was applied. In this technique, the guards were asked to refer additional guards and officers to be interviewed. The names of forest guards were redacted from this study to allow them the safety of anonymity.

The interview was carried out in English, transcribed, and coded using Delve Tool qualitative analysis obtained from delvetool.com to categorise the transcript into five themes. Then, an in-depth content analysis of the data was carried out. Essentially, coding involves arranging and summarizing the appropriate content of qualitative data into themes by using words, phrases, sentences, or paragraphs that best described or capture the response. As a result of coding, data can be easily organised, analysed, and interpreted to produce an informative report (Linneberg & Korsgaard, 2019). The survey was collected from the CRS by enumerators in December 2021. They were Nwaeche Chiemerie, Gabriel Otolorin, University of Uyo, Akwa, Ibom State, Nigeria, and Dr Lauretta Ofodile, Yaba College of Technology Lagos State, Nigeria.

Purposive sampling is one of the non-probability sampling techniques. It is also known as judgmental, selective, or subjective sampling. The method involves selecting subjects from a population according to the study's purpose. Sites, places, organizations, individuals, or groups of individuals that are relevant to the issue of interest being investigated are identified and selected for the research. Moreover, participants are also selected on criteria such as availability, experience, knowledge of the research issue, and willingness to participate in the study. In essence, the researcher identifies a population whose characteristics are of interest, determines what information is needed, and reaches out to people who are willing to provide answers to the research questions. A purposeful sampling technique can be applied to both qualitative and quantitative research (Asiyanbi et al., 2017; Etikan & Bala, 2017; Etikan, et al., 2016; Rai & Thapa, 2015; Tongco, 2007).

Snowball sampling, on the other hand, is one of the most used in qualitative research. This method serves as a principal means of obtaining new participants or social groups to participate in research. To select participants, the researcher uses the contact information given by the initial respondents to reach out to the next respondents. The method can be beneficial when the researcher is unfamiliar with the target group or organization under study. A probability or non-probability method can be used to choose the initial respondents (Acharya et al., 2013; Etikan & Bala, 2017; Noy, 2008).

3.5.3. NDVI data collection and extraction method

Additionally, this study also used the NOAA Advanced Very High-Resolution Radiometer (AVHRR) Version 5 NDVI data for quantitative analysis. The vegetation data were obtained to analyse the forest change in the CRS, Nigeria. The 1-km AVHRR spatial resolution images were obtained from noaa.gov. website. The AVHRR satellite raster images with the same date and month were selected. The dry season images (December) were selected to minimize discrepancies which may be caused by seasonal variations in vegetation, water, cloud cover and sun angle as information in satellite images is obscured by these factors (Adeyemi & Oyeleye, 2021; Ayanlade & Howard, 2017; Rahaman et al 2022). The month of December was also chosen since most annual crops are likely to have been harvested. The images were analysed using Quantum Geographic Information System (QGIS). Data for all months of the year analysed were available. The AVHRR raster layers were imported into QGIS software along with Nigeria GRID3 operational LGA administrative boundaries level 1 to extract the mean NDVI values.

The NDVI time series data represent the 10 years before (2000-2009) and 10 years after (2010-2020) the implementation of REDD+ in CRS. Thirty-one images were processed for each December month of the year. The administrative boundaries shapefile used was released in September 2020 and obtained from https://data.grid3.org. For the two CRS LGAs, zonal statistics were calculated and NDVI values were extracted. To determine the data analysis type, a normality test was used to determine if the mean NDVI data were normally distributed. Descriptive statistics were carried out through a computer-generated normal distribution using MS Excel. MS Excel is one of the software available for statistics and sample size calculation (Ali & Bhaskar, 2016).

The autocorrelation function, partial correlation function and Ljung-Box tests were used to check for autocorrelation in the autoregressive integrated moving average (ARIMA) model of this study. ARIMA is a basic stochastic time series model used to forecast future time points. ARIMA captures complex relationships that are not as straightforward as they seem by applying error terms and observing lagged terms (Brockwell & Davis, 2002; Hamilton, 2020). Furthermore, Ordinary Least Squares (OLS) regression and parametric t-tests were also used to evaluate the effect of the REDD+ program on the forests of Akamkpa and Boki LGA, CRS, Nigeria. The results of the analysis were compared.

3.6. The Normalized Difference Vegetation Index (NDVI)

Information regarding the spatial and temporal dynamics of the earth's land cover is critical for regional and global change research. It is useful in studying land-climate interactions and tropical deforestation rates, as shown in several studies. Over the years, the use of the National Oceanic and Atmospheric Administration (NOAA) Advanced Very High-Resolution Radiometer (AVHRR) has been recognized. As a result of AVHRR-derived NDVI images, it is possible to study and monitor changes associated with deforestation, vegetation productivity, condition, greenness, and vegetation dynamics on a regional and global scale. Several authors have used this method in academic literature (see Ichii et al., 2003; Ji & Brown, 2022; Beck et al., 2011; Gonzalez-Jaramillo et al., 2016; Giglio & Roy, 2022; Malingreau et al., 1995; Martínez & Gilabert, 2009). Remote sensing data can also provide land use information that may be combined with socio-economic data in research (Etter et al., 2006; Foresman et al., 1997; Nagendra, 2004; Ganasri & Dwarakish, 2015). Hence, its use in this study.

The AVHRR record started in the 1980s. Due to this, it has amassed lengthy and consistent data records of surface reflectance and vegetation indices. Although, the newer generation sensors such as MODIS offer instrumental specifications, geometric registration, spectral calibration, and radiometric correction. AVHRR satellite systems and sensors provide the most extended time series of satellite NDVI images. Thereby, it presents an advantage for long-term vegetation trends and variations studies (Ji & Brown, 2022; Wu et al., 2020; Claverie et al., 2016). The NOAA Climate Data Record (CDR) of the AVHRR Version 5 contains a gridded daily Normalized Difference Vegetation Index. It provides a consistent, long-term record of global surface vegetation coverage activity based on remotely sensed observations (Vermote, 2019; Zhao et al., 2022). Pettorelli (2013, p. 71-79) describes the Normalised Difference Vegetation Index as a graphical indicator for assessing spatial and temporal changes in green vegetation.

According to Vermote (2019), the NDVI values come from surface reflectance calculations in the red and near-infrared spectral bands captured by AVHRR. This CDR produces daily output on a 0.05 by 0.05-degree global grid using data from 1981–to the present. The dataset is one of the land surface CDR Version 5 products produced by the NASA Goddard Space Flight Centre (GSFC) and the University of Maryland (UMD). The improvements for Version 5 include improved surface reflectance data, corrections for known errors in the time, latitude, and longitude variables, as well as improvements in the global and variable attribute definitions (ibid). NDVl values are high in pixels with high green biomass. In NDVI compositing, the highest NDVI pixel is retained for each composite period. Additionally, the magnitude of the NDVI varies from year to year because of differences in sensors, view angles, and atmospheric conditions. Therefore, Sader & Winne (1992) and Senay & Elliott (2000) observed that averaging months or years of data (mean NDVI) would eliminate sudden and unexplained irregularities in the NDVI.

NDVI is calculated from the visible and near-infrared light reflected by vegetation. The principle around this is that a healthy plant absorbs most of the visible light that encounters it and reflects a large portion of the near-infrared light. On the other hand, unhealthy and sparse vegetation reflects more visible light and less near-infrared light. The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides them by the sum of near-infrared and red bands (Bid, 2016; Kashyap & Kumar, 2021). The calculations of NDVI result for a given pixel range from -1 to +1. Green leaves do not give zero values, zero value means a lack of vegetation. It has been demonstrated that a zero value represents bare soil, while an extremely negative value represents water. With a value greater than 0.5, the pixel is considered fully vegetated. However, the highest possible density of green leaves is 0.8 to 0.9 (Al-Azzawi, 2018; Biswal et al., 2013; Me et al., 2016). NDVI is calculated thus,

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

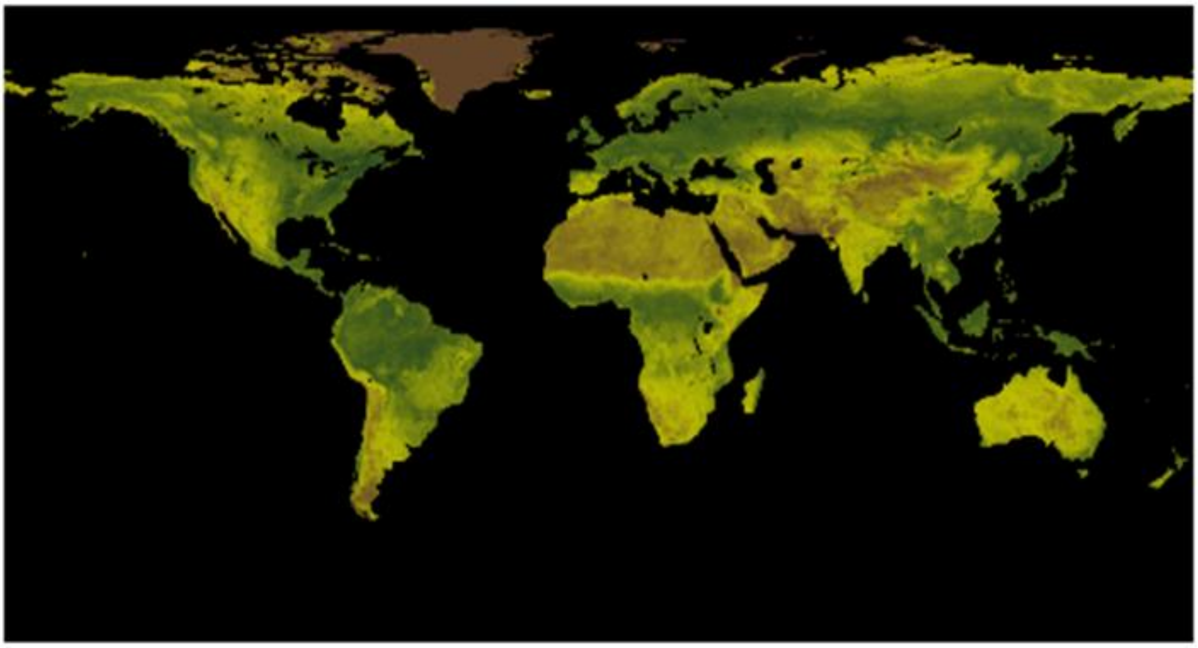

Figure 3. The Global image of daily AVHRR NDVI (https://www.ncei.noaa.gov)

Table 1: Summary of data types used in this study and their purpose

Category of primary data	Type	Coverage	Purpose
Remote Sensing Data	NOAA AVHRR raster images	Six hundred and twenty (620) processed raster images from 2009 to 2019	For forest change analysis in CRS, Nigeria.
Maps	OpenStreetMap and Nigeria	The road network, settlements, and rivers in CRS and	To assess the roles of the road network and settlement expansion on the rate of deforestation in CRS forest reserves.
	GRID 3 Administrative Map	Zonal Statistics calculations	To Zonal Statistics calculations
Social Data	Questionnaire	One hundred and sixty (160) questionnaires were administered to the forest communities around the REDD+ sites.	To collect information on the type of forest resource often used, factors causing conflict, alternative livelihood, the REDD+ program and how to participate in their communities.
	Interview	A one-to-one interview with eight forest officers and guards in December 2021.	The interview will centre on REDD+ achievement, challenges and perceived issues causing conflict.
Secondary data	Journals, REDD+ reports and publications.	Nigeria REDD+ Readiness Preparation Proposal (R-PP), 2013.	To identify the locations of REDD+ pilot sites and the communities around REDD+ in CRS areas in Nigeria and obtain information from some past research.

Source: Adapted from Ayanlade & Howard (2017).

3.7. The REDD+: Aim and mechanism

Over three decades, it has been largely accepted by the scientific community that climate change is currently impacting the ecosystem. In the future, this negative impact is likely to continue, and its magnitude is yet to be seen. The ability of the forest to offset large quantities of atmospheric carbon dioxide (CO_2) and mitigate climate change has been demonstrated in many studies. According to scholars, the forest can sequester carbon in both woody biomass and soils (see Cai et al., 2022; Malhi et al., 2002; Paniagua-Ramirez et al., 2021; Qubaja et al., 2022; Raihan et al., 2019; Siraj, 2019; Zhao et al., 2010; Pugh et a., 2019; Soares-Filho et al., 2010; Forster et al., 2021; Doelman et al., 2020; Eliasch, 2012). The primary objective of the REDD+ program is to reduce carbon emissions, mitigate the negative effects of climate change and limit global warming to 2°C (Ahmed et al., 2017; Fawzy et al., 2020; Levin & Cashore, 2008).

Funds for REDD+ implementation and incentives are provided by developed countries to developing countries to engage in activities that can mitigate climate change (Cadman et al., 2017; Nuesiri, 2016). Thus, the REDD+ concept is centred on sustainable forest management and conservation practices that reduce forestry and land-use-related emissions. Consequently, the ability of the forest to absorb more carbon dioxide would be enhanced. In this context, REDD+ emerged as a key international strategy to pay for carbon dioxide that is conserved in trees (Corbera & Schroeder, 2011; Skutsch et al., 2009). It is assumed that if forest communities are compensated, they will cooperate in forest conservation. This makes up for initial efforts and future carbon reduction in the forestry sector (Angelsen et al., 2012; Streck, 2021; Turnhout et al., 2017; Isyaku, 2021).

Although there was an initial grand consensus on REDD+, the concept has been restructured. This is due to the conflict of interest among countries and the absence of an international climate change agreement. After the year 2005, some new objectives were added. These include the improvement of local livelihoods, protection of biodiversity, and co-benefits. The goal was to strengthen indigenous rights, have better governance, and increase climate change adaptation capacity. REDD+ is also increasingly linked to the agriculture climate agenda. As a result, REDD+ has more objectives than it did at the beginning (Adger et al., 2003; Angelsen et al., 2012; Corbera & Schroeder, 2011; Maukonen et al., 2017). Thompson et al. (2010) noted that the governing of the UN-REDD program is vested in a policy board made up of representatives from the REED+ partner countries, multi-donor trust fund, civil society, indigenous people, and the United Nations agencies. The policy board is responsible for the overall leadership, strategic direction, and financial allocations for all UN-REDD activities.

As required by the World Bank, each participating country addresses equitable benefit sharing, incentives for REDD+, and improvement of local livelihoods in their readiness plan. The Forest Carbon Partnership Facility (FCPF) and UN-REDD recognize the importance of institutions, governance, sustainable livelihoods, social-cultural and conservation of biodiversity inclusion in REDD+ (Bayrak & Marafa, 2016; Roe et al., 2013). Benefit-sharing in REDD+ refers to financial incentives as well as other benefits from international funds or carbon markets. The mechanisms involve compensation related to the opportunity costs of maintaining forests in their natural state (Angelsen et al., 2012; Gebara, 2013; Howson, 2018).

Another aspect is providing incentives to motivate local forest users to behave positively. Benefits are distributed among stakeholders (communities, landowners, governments) within a country that uses its forest according to REDD+ policies. It also involves institutions, governance structures, and mechanisms for distributing the benefits (Maguire, 2018; Mustalahti & Rakotonarivo, 2012; Chapman et al., 2015; Guerra & Moutinho, 2020). However, the pilot country must have generated positive results before an incentive is given. Although the initial funds are given to start the program in a country (Angelsen, 2017; Dunlop & Corbera, 2016). Benefits can be given up-front to allow REDD+ to begin or distributed subsequently to ensure REDD+ actions continue as needed. Roe et al., (2013) maintain that one of the potential co-benefits of REDD+ and forest carbon projects is to enhance the livelihoods of local communities.

According to Angelsen et al. (2012), benefit-sharing can be classified into two broad categories. These are vertical benefits that involve national and local level stakeholders and horizontal benefit-sharing which occurs between and within communities, households, and other local stakeholders. Additionally, a benefit may be monetary (cash) or non-monetary. Non-monetary benefits include livelihood enhancement, employment, capacity building, knowledge transfer, biodiversity protection, and infrastructure development (Angelsen et al., 2012; Roe et al., 2013; Mustalahti & Rakotonarivo, 2012). Benefits can also be received through the development of entrepreneurship, and access to markets for crops (Peras et al., 2016). However, the institutional choice used in establishing the benefit-sharing mechanism may have an impact on the entire structure of REDD+ programs (Mustalahti & Rakotonarivo, 2012). According to Chapman et al. (2015), the establishment and distribution of carbon revenues and other non-monetary benefits across all levels of REDD+ are challenging because there is no explicit guidance on how to manage them.

Although a general guideline for REDD+ activities was provided by the Forest Carbon Partnership Facility of the World Bank. Despite this, it is up to individual countries to determine carbon rights and manage the sharing of the benefit within their respective national programs (Carter et al., 2021; Davis et al., 2009). Concerns have been raised using cash incentives. some people may be interested in participating in REDD+ because of the carbon credit while others may be unwilling to participate due to interference with their livelihood (Acharya et al., 2009; Isyaku, 2021; Saeed et al., 2018). Skutsch et al. (2009) argue that local communities may receive a very small or no financial value from the carbon money. The funds sometimes end up at the state and intermediary levels.

Saito-Jensen et al. (2014) break this down further. In developing countries, many rural people lack forest tenure and have little power. States and commercial actors can allocate or apportion forest lands and claim incentives. Thus, it is unlikely that forest-dependent communities will receive their fair share of the REDD+ payments. If the benefit is not equitably and transparently distributed among all stakeholders, forest-dependent communities may continue to exploit and destroy the forest. The future of REDD+ could be jeopardized by this. Therefore, REDD+ is not merely about improving forests or having a clear principle and design. The legitimacy of the decision-making institutions is crucial to the effective implementation of benefit-sharing to obtain the main rationale behind REDD+. It is necessary to take this into consideration. Stakeholders in REDD+ include local communities, governments, concession holders, project developers, and facilitators (Angelsen et al., 2012; Luttrell et al., 2012; Luttrell et al., 2013; Roe et al., 2013).

As required by the World Bank, each participating country addresses equitable benefit sharing, incentives for REDD+, and improvement of local livelihoods in their readiness plan. The Forest Carbon Partnership Facility (FCPF) and UN-REDD recognize the importance of institutions, governance, sustainable livelihoods, social-cultural and conservation of biodiversity inclusion in REDD+(Bayrak & Marafa, 2016; Roe et al., 2013). It is worth emphasizing that the REDD+ financial support is rendered as a results-based incentive for countries that are tackling deforestation and sustainably managing their forests. This has remained the fundamental part of REDD+ (Angelsen et al., 2017; Wong et al., 2019). Therefore, credible and reliable data must be produced through continued efforts by REDD+ countries, most especially in deforestation estimates (Sandker et al., 2021).

It is worth mentioning that most forest carbon investment occurs in the voluntary carbon market as part of corporate social responsibility and philanthropic contribution. REDD+ is largely financed by the private sector and bilateral or multilateral donors. They pledged more than 89% of the REDD+ and forest-related funds (Norman & Nakhooda, 2015). Therefore, the REDD+ credits are uncertain in the carbon market due to the lack of security of funds (Miah & Aturo, 2021). Examples of these funding bodies are the Forest Carbon Partnership Facility (FCPF), the Forest Investment Program (FIP), the Amazon Fund, the Congo Basin Forest Fund (CBFF) and the BioCarbon Fund Initiative for sustainable forest landscapes (Gupta, 2012; Norman & Nakhooda, 2015).

For instance, the FCPF initiative is a programme of the World Bank that is built on multi-donor funds of governments, non-governmental agencies, and private companies. It collaborates between developing countries, donors, and private sector participants. FCPF has been funding pilot schemes for emissions reduction and result-based payments generated from REDD+ activities (Cadman et al., 2017). FCPF developed a framework for REDD+ readiness that assists countries in preparing for the full implementation of REDD+. Regardless of the institution created to regulate the use and management of forest resources, they all aim to achieve several objectives. Among their goals are the conservation or restoration of forests, the enhancement of species diversity, and the improvement of forest dwellers' well-being and income. The latter is related to poverty reduction. Furthermore, they ensure that all groups are well represented and that the cost and benefit of forest management are distributed equally (Kimengsi et al., 2022; Vatn & Angelsen, 2009).

The United Nations Framework Convention on Climate Change (UNFCCC) allocate the initial funds to the developing countries involved in the REDD+ program. These funds are directed toward the preparation and planning activities at the international and regional levels (Cadman et al., 2017). However, the provision of results-based climate finance payments is based on certain criteria. These criteria have been defined by the Warsaw Framework for REDD+ (WFR). The criterion stipulates how the reduction of GHG emissions and enhancement of forest carbon stocks must be measured, documented, and proven before payment can be made (Streck, 2020). Despite this, there has not been a binding national carbon cap established in the Paris Agreement to increase demand for global carbon trading and a global carbon market has not materialised (Angelsen et al., 2017; Michaelowa et al., 2019). Miah & Aturo (2021) maintain that the majority of forest carbon investment occurs in the voluntary carbon market, which is a form of philanthropic contributions and corporate social responsibility. Consequently, REDD+ credits are uncertain in the carbon market due to a lack of funding security. This presents a challenge to the future of REDD+.

Studies have demonstrated that REDD+ has encountered several challenges in their implementation and has achieved limited success in addressing forest loss and degradation reduction (Milne et al., 2019). Isyaku (2021) noted that implementing REDD+ in community forests in low-income countries can be problematic since it may destabilize a functioning governance system. Apart from this, politics (Riva et al., 2022), resistance, and structural inequalities, especially in many rural African countries have been reported. Forest communities are of the opinion that REDD+ is a program designed to benefit a particular group of individuals or reduce indigence. Furthermore, bad forestry governance, the variability of income from carbon sales and the vacillation of alternative livelihood opportunities for forest-dependent communities have also been identified as significant problems (Gupta, 2012; Lestari, 2019; Scheba, 2018).

Other difficulties in REDD+ include social conflict (Milne et al., 2019), land tenure rights, implementation of REDD+ regulations and legislation (Thompson et al., 2010), property rights (Asiyanbi, 2016) and corruption (Fadairo et al., 2018). Moreover, there are issues associated with land grabs, evictions, forest access restrictions (Lawlor et al., 2013) and the distribution of benefit-sharing (Gebara, 2013; Soliev et al., 2021). In many people's views, REDD+ is supposed to be a win-win initiative but not everyone is experiencing the expected benefit of the REDD+ program (Poudel et al. (2015). This implies there are evolving issues that need to be addressed as REDD+ projects advance. However, in some countries, REDD+ is making some progress in achieving emission reduction (Kim et al., 2021).

3.8. REDD+ in Nigeria: Prior forest management system in Cross River state, the REDD+ and local participation

Studies have shown that some of the CRS forest communities have a long history of practising voluntary conservation before REDD+. Several conservation initiatives have been promoted since 1990, such as those sponsored by NCF/WWF in 1990-2000, ODA/DFID in 1999-2001, and the Living Earth Nigeria Foundation initiative in 1998 (Emeh & Oden, 2005; Jimoh & Abi, 2013). The most acknowledged community forest conservation initiative in Cross River State is the Ekuri community. In 1992, the Old Ekuri and the new Ekuri villages (six km apart) jointly established the Ekuri Initiative under community-based forest management. This was done to conserve and manage their forest for community development purposes (Ahove, 2017; Oyebo et al., 2010). As a result, they were able to reduce illegal forest activities in the Ekuri region. The enforcement of forest and wildlife conservation laws as well as the involvement of local communities also played some part in this success. Some of the Ekuri Initiative's accomplishments include the inventory of two 50-ha forests where timber was sustainably harvested and the development of a land-use plan that zones the Ekuri forests into different land uses. Moreover, a 40km-long road was constructed through this initiative for the people living in the forested areas of CRS (Wily, 2002; Asiyanbi et al., 2019; Oyebo et al., 2010). Asiyanbi et al. (2019) and Onojeghuo et al. (2016) maintain that the Ekuri community is managing its forests through indigenous institutions that are still operating.

Another example is the Conservation Association of the Mbe Mountains (CAMM) established in 2005. It is traditionally believed that nine surrounding communities own the Mbe forest. CAMM negotiates boundaries, establishes common zones, and manages the gorilla habitat. They bridge conservation voids in the CRS through the establishment of local institutions and provide financial support to keep conservation activities going with the surrounding forest communities (Dunn et al., 2014; Ite, 1996; Okoro & Ogbuefi, 2016).).Furthermore, in 2004, the Sustainable Practices in Agriculture for Critical Environments (SPACE) project was launched in CRS. The main objectives of the SPACE project were to protect the ecological values of the forests in Cross River State and to slow the expansion of agriculture into forests by promoting sustainable agriculture. The organization hoped to improve the welfare of communities located near these forests. This project involved the Afi River Forest Reserve, the Afi Mountain Wildlife Sanctuary, the Mbe Mountains, the Okwangwo Division of the Cross River National Park (CRNP), as well as the Cross River South Forest Reserve in the Oban Hills Division (Oyebo et al., 2010). Farmers were trained in better tree management techniques as part of the capacity building to manage the cocoa trees sustainably. However, the programme ended in 2007 due to a lack of funds (Oyebo et al., 2010).

A forest governing body also existed at some point in the CRS. Between 1998 and 2001 the Forest Management Committee (FMC) was established in CRS with the assistance of the Forestry Commission. The committee focuses on timber and Non-Timber Forest Products (NTFPs) management issues. It provided forest communities with the opportunity to participate in forest management, decisions, and resources benefit. Eighteen FMCs were certified and given due recognition by the CRS government in 2004 to serve the forest communities. The FMCs facilitated the development of zoned land use maps, community land use plans, and community bylaws. Sustainable agricultural practices were also at the centre of some of the forest management projects in CRS. However, the FMC was unable to protect and manage forest resources effectively. The committee was dissolved when some community forestry projects ended (Enuoh & Bisong, 2015; Oyebo et al., 2010).

Several works of literature have highlighted the importance of the CRS forests for their richness in biodiversity and species of wild animals. The forests are part of the Guinean Forests of West Africa global biodiversity hotspot and among the last habitats for the rare western gorilla subspecies. The forests are crucial for the survival of endangered and critically endangered wildlife species such as the Cross-River gorilla (*Gorilla gorilla diehli*), with a total population estimate of 300 individuals, the Nigeria–Cameroon chimpanzees (*Pan troglodytes ellioti*) and drills (Mandrillus leucophaeus) (Krause et al., 2019; Friant et al., 2019; Enuoh & Ogogo, 2018; Udumo et al., 2020; Maukonen et al., 2017). Furthermore, the forests are also a habitat for a variety of birds, including Baumann's Greenbul (*Phyllastrephus baumanni*), Grey-necked Picathartes (*Picathartes oreas*), and the largest roost site of barn swallows (Hirundo rustica) in Africa (Nuesiri, 2006). In addition, it hosts endangered species of baboons, buffaloes, manatees, monkeys, and black elephants. This makes it one of the ultimate tourist destinations in Nigeria (Oku, 2022).

The tropical rainforest's unique biodiversity makes it a very important part of ecotourism (Fon et al., 2014). The CRS is not only home to wild animals and plants, but also cultural and natural sites with an international significance for tourism purposes. Some of the tourist sites include waterfalls, monoliths (carved and engraved stones dating back to 1200 BC), cultural festivals and the Obudu mountain resort. Tourism has positively impacted the socioeconomic condition of CRS by creating jobs and business opportunities (Ajake, 2016; Amalu et al., 2021; Oku, 2022). However, the forest cover in Cross River State is decreasing (Maukonen et al., 2017) and the ongoing illegal hunting and habitat loss continued to affect the natural resources negatively (Krause et al., 2019).

In 2010, Nigeria became a member of the UN-REDD program as a strategy to strengthen the forest institutions, conserve the remaining forest cover, and contribute to climate change mitigation (Isyaku, 2021; Nuesiri, 2016; Maukonen et al., 2017). Additionally, the REDD+

program is expected to provide ecological, economic, and biodiversity benefits to Nigeria (Awoniyi & Amos, 2016). According to recent studies, the larger percentage (50%) of the remaining tropical high forests in Nigeria are in Cross River State (Fon et al., 2014; Krause et al., 2019, Maukonen et al., 2017). Consequently, the Cross River State was selected as Nigeria's first REDD+ pilot state (Krause et al., 2019). Nigerian plans for REDD+ readiness encompass strategies for social development, including capacity building, governance, equitable benefits sharing, and respect for local norms and values. (Isyaku, 2021; Roe et al., 2013). REDD+ is anticipated to directly impact forest communities' livelihood by REDD+. This calls for the involvement of local authorities in decision-making in the REDD+ program (Nuesiri 2017). However, local government authorities and many forest communities were not part of the decision-making process that resulted in the establishment of REDD+ in CRS, Nigeria (Asiyanbi, 2016; Nuesiri, 2017).

As explained by Ribot (2008, p. 1), local democracy serves as a platform for local leaders to respond to their citizens' needs and aspirations. In other words, people express their concerns and trust their leaders to address them (Nuesiri, 2016). Likewise in Nigeria, local government areas are created in part to facilitate community engagement in development issues (Ovat, 2015). However, during the first and second REDD+ meetings, participants were primarily from the forestry commission, NGOs, and selected individuals who represented a larger number of forest communities. The Ekuri community had eight participants in the first meeting and 22 in the second meeting. Although this group represented the local communities, they may not report back to them. further, there were claims that local government officials were not good administrators, which was one reason they were excluded from the CRS REDD+ process. Additionally, they are believed to be inefficient when compared with state or national elected officials. Nevertheless, some individuals considered this groundless and unreasonable point (Nuesiri, 2016, Nuesiri, 2017; Asiyanbi, 2016).

A low rate of local community participation in REDD+ in the CRS has been reported (Amuyou et al., 2021). Local people and authorities may play a vital role in REDD+ if they are engaged. An example is Pakistan, where local authorities helped to devise a plan to achieve certain REDD+ activities such as monitoring and assessment because of the lack of a central forest monitoring, reporting and verification system (Vatn & Angelsen, 2009). Therefore, it has been suggested that local support and interventions tailored to high deforestation and forest degradation areas are key to the REDD+ success and for conservation efforts to be effective

(Ezebilo, 2012). If local people perceive that the future value or benefits of a community forestry project are high, they are most likely to participate in the project (Horowitz, 1998; Hackel, 1999).

3.9. Description of the REDD+ sites in CRS, Nigeria

There are three (3) active REDD+ pilot sites in the Cross River State. The Ekuri-Ukpon River forest reserve, the Afi/Mbe Mountains River Forest, and the Cross River mangrove forest reserve. Afi/Mbe and Ekuri-Ukpon forest clusters (approximately 50,000 ha) include both community forests and forest reserves. It is jointly managed by local communities, the CRS government, the Forestry Commission, and conservation organizations. The protected areas in the Afi-Mbe forest cluster include the Afi Mountain Wildlife Sanctuary, the Afi River forest reserve, and the Mbe Mountains. Additionally, it encompasses the Okwangwo Division, a community forest located south of the Cross River National Park (CPRN). The Afi River forest reserve is in the Boki local government area. The Ekuri-Ukpon cluster comprises the Ukpon River forest reserve, Ekuri community forest, and part of the Oban Block Forest reserve (Oyebo et al., 2010; Awoniyi & Amos, 2016). In CRS, some of the villages located near these forests and protected areas include Bashu, Bashua Danare, Bendeghe Afi, Iso Bendeghe and the 9 Abo villages.

All these villages have been supported in the past by the UK Department for International Development (DFID) and the Living Earth NGO community forestry programme. On the other hand, the Ekuri-Iko Esai-Okokori - Etara-Eyeyeng - Owai - Ukpon River forests are in the Akamkpa. Obubra and Etung LGA of Cross River State. These forest shares a boundary with the Cross River National Park, the Iko Esai land, and community farmlands. Iko Esai’s forests are contiguous with Old and New Ekuri. Some of the villages around the Ekuri – Iko Esai forest reserve are Ekuri, Iko Esai Okokori. Etara, Eyeyeng and Owai (Onojeghuo et al., 2016; Geraldine & Emmanuel, 2016; Fon et al., 2014; Oates et al., 2004). The Cross River National Park (CRNP) was established in1991 and it is divided into two parts, namely; the Okwangwo Division and the Oban Division. The Okwangwo Division is separated by 50 km from the Oban Division. The Oban Forest Reserve Division is approximately 342,459km2 South-East of Nigeria and it is contiguous with Korup National Park in Cameroon (Obong et al., 2013; Oates et al., 2004). The Okwangwo Division (640 km2, north of the Cross), was created from the former Okwangwo, Boshi, and Boshi Extension Forest reserves (Oates et al., 2004). According to Djurfeldt et al. (2017), Okwangwo is an enclave community within the Cross River National

Park (CRNP). The land is extensively used for farming as a primary occupation. The human population in this area is growing rapidly and demand for farmland is leading to encroachment in parts of the National Park (Obong et al., 2013).

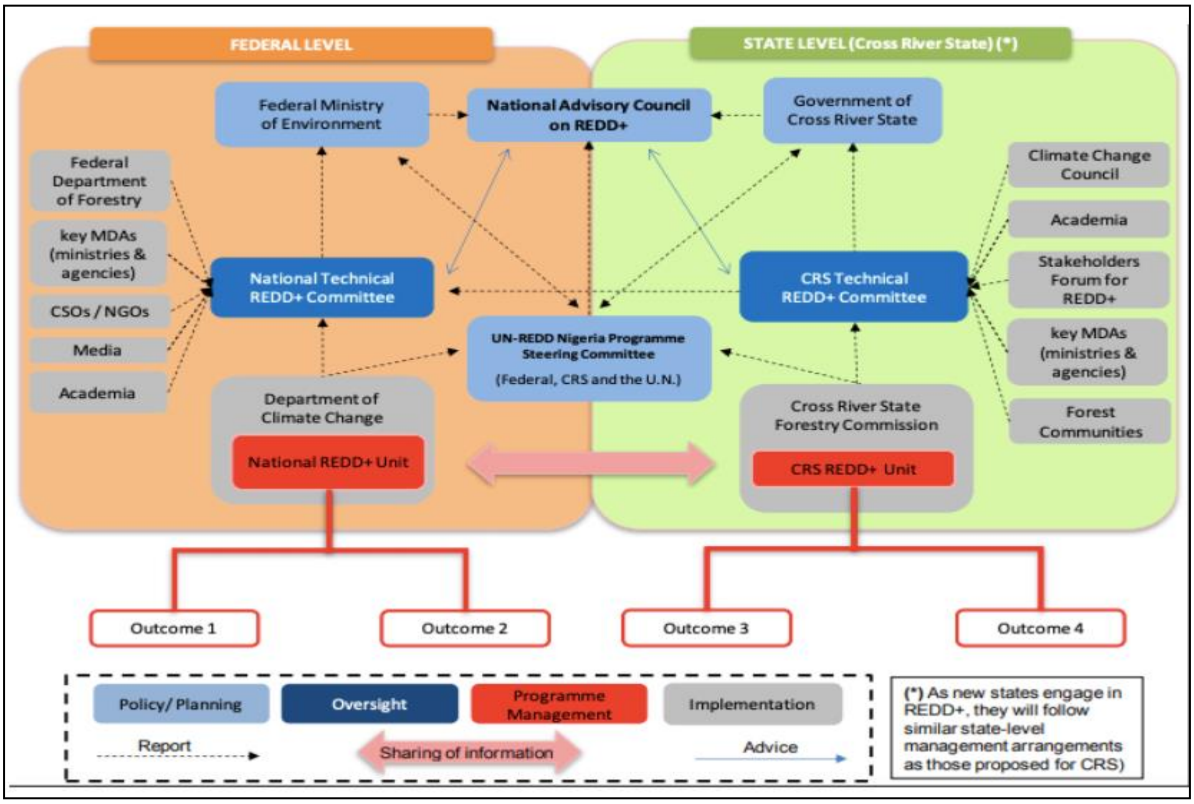

Figure 4. An organisational chart of the REDD+ readiness process in Cross River State (CRS), Nigeria (Van, 2020).

3.10. REDD+ Evaluation

To determine whether the REDD+ project was successful or not, a comprehensive impact assessment is necessary. This accounts for parameters such as carbon stocks, forest cover and forest use among other factors. Furthermore, donors and project promoters demand ideas and information on how the project has turned out or how it can perform better. The exchange of such data can serve as a platform for sharing valuable information that will assist in the formulation of policies and decisions. In this regard, it is imperative to collect baseline data prior to project implementation to estimate the impacts before and after project implementation (Jagger et al., 2009; Jagger et al., 2010, p. 1-20). Researchers have explored different ways to account for the impact of the REDD+ program. The direct and indirect impact of REDD+ can be measured on factors such as property rights, forest loss and carbon reduction, non-carbon benefits, livelihood, culture, political systems, and as well as health and well-being (see Bayrak

& Marafa, 2016; Duchelle et al., 2018; Pandey et al., 2014; Maniatis et al., 2011; Sangermano et al., 2012). In most projects, impact evaluations are often conducted after the project has started. This makes it challenging to assess and ascribe changes accordingly (Jagger et al., 2010, p. 1-20).

According to Caplow et al. (2011) and Guizar-Coutiño et al. (2022), there is no fixed methodical approach to assessing REDD+ impact which makes it difficult. To achieve this aim, researchers have used the mapping method, Landsat NDVI time-series, multispectral imaging (see Akhtar et al., 2020; Beaudoin et al., 2016; Bos et al., 2019; Guizar-Coutiño et al., 2022, Lu et al., 2012; Skole et al., 2021) and Counterfactual NDVI time series (Roopsind et al., 2019). Literature also suggests the use of a mixed-method approach featuring questionnaires, focus groups and interviews (Solis et al., 2021; Flanery et al., 2022). Caplow et al. (2011) argue that when assessing the impact of a project such as the REDD+, counterfactuals (what would have happened without a project) using control and intervention site data is vital. Counterfactuals involve methods such as the before-after (BA) and before-after-control-impact (BACI) analysis. Data from the control and intervention sites is collected before and after the intervention to estimate the impact.

It is paramount to highlight that this type of outcome measurement may be insufficient because biophysical, socioeconomic, as well as political factors influence the adoption and implementation of REDD+ projects in different countries. These factors may change a forest even without interventions. Moreover, the BACI may be insufficient due to its limitations. The lack of a true control (the control site has different characteristics), bias (Caplow et al., 2011; Jagger et al., 2009; Jagger et al., 2010, p. 1-20) and overestimation of counterfactuals (Cuenca et al., 2016; Jones & Lewis, 2015) are examples of such issues. For instance, in the carbon emission reduction assessment of the Brazilian Amazon REDD+ projects, West et al. (2020) found that the calculated mitigation against counterfactual forest losses was overestimated (ibid). Therefore, it is crucial to select appropriate control areas that have similar attributes to the original site, but this can be challenging and nonexistent (Bos et al., 2017).

Although Duchelle et al. (2018) maintain that there is a paucity of studies on counterfactual scenario outcomes of REDD+. A few studies have applied the counterfactual method to measure the impact of REDD+ activities (see Bos et al., 2017; Caplow et al., 2011; Carrilho et al., 2022; Sharma et al., 2020; West et al., 2020). Furthermore, comprehensive impact evaluations require considerable investment because they are complex and costly to conduct

(Caplow et al., 2011). According to Jagger et al. (2009), quantitative data such as remote sensing methods may lack a breadth of information. This calls for a mixed methods approach that takes ethnography, participatory rural appraisal, key informant interviews and socioeconomic surveys into account.

A community survey may include questions about the infrastructure of the community, people's perceptions, and the benefits of participation in community activities. Such data can provide an in-depth view and knowledge of implementation and the interactions between interventions and their outcomes (Caplow et al., 2011; Jagger et al 2009; Jagger et al., 2010, p. 1-20). Duchelle et al. (2018) classified the methodological approach used to measure REDD+ outcomes as a case report (assessing intervention outcomes without comparators) with qualitative or quantitative evidence based on trends but without inference or causality assessments; case-control comparison (using a control area or comparison of before-after outcomes) without considering confounding variables; case-control comparison with some consideration of confounders; case-control comparison with a rigorous selection of controls through pre-matching; randomized control trial, or random assignment of treatment and control categories to eliminate selection bias; and meta-analysis or systematic review.

3.11. REDD+ outcome

Assessment and analyses of case studies show that many countries have not yet achieved the aims and objectives of the REDD+ program. There were cases where REDD+ reduced deforestation and achieved very low emissions reductions at the early stage of the project implementation. Such were the case studies by Guizar-Coutiño et al. (2022) whose analysis indicate deforestation reduction and 0.01% emissions reduction of forty voluntary REDD+ in nine tropical countries located in Africa, Southeast Asia, Oceania, and Latin America when compared to the global emissions level in 2018. In terms of reducing forest cover loss, Roopsind et al. (2019) discovered that the Norway-Guyana REDD+ program reduced tree cover loss by 35% during the implementation. However, an increase in forest loss was observed after the incentive stopped. Likewise, Carrilho et al. (2022) also recorded a similar result in the Brazilian Amazon REDD+ project where the program conserved an average of 7.8% to 10.3% of forest cover per household. Following the end of the project, forest loss resumed. This indicates that the program did not eradicate deforestation and without continued payments, forest protection is not guaranteed.

Regarding well-being, the findings of REDD+ implementation in different countries explored by Duchelle et al. (2018) were not desirable. However, there were few positive results on land use and carbon emission reduction. These authors suggest that local community involvement, funding, and carbon and non-carbon outcomes should be considered in REDD+. Studies indicate that some REDD+ projects have closed and only a few have sold carbon credits. This is evidenced in Sunderlin et al. (2015) evaluation of twenty-three REDD+ projects in Brazil, Peru, Cameroon, Tanzania, Indonesia, and Vietnam where only four REDD+ projects sold carbon credits at the time of the report. A similar study was conducted by Bos et al. (2017) on twenty-three REDD+ initiatives in Brazil, Peru, Cameroon, Tanzania, Indonesia, and Vietnam to evaluate the effectiveness of the REDD+ program in reducing deforestation. It was found that the outcome of REDD+ was not very positive.

In a study published by Duchelle et al. (2018), more than 350 localized REDD+ projects have been implemented across the tropics. Few projects have applied the incentives considered the core innovation of REDD+. Only one-third of the projects have sold carbon credits on the voluntary carbon market as of early 2018. Uisso et al. (2021) argue that non-carbon benefits may be a key component of REDD+. Furthermore, not all REDD+ programs have completed the carbon verification process after a decade of implementation. In Tanzania, carbon payment is yet to be realised and co-benefits have no improvement on forest cover (Collins et al., 2022)

In Nigeria, limited studies have explored the benefit and impact of REDD+ on socioeconomics and forest cover. There has not been much optimism in the reports. Onojeghuo et al. (2016) noted a reduction in the annual deforestation rate within the protected areas of CRS REDD+ sites. The positive change was attributed to a rise in afforestation. However, the mangrove forest experienced deforestation during the year investigated. Logging, agriculture, fuelwood, population growth, and industrialization were the factors mentioned to be responsible for forest loss in the mangrove forest. Despite Akamkpa forest reserves being part of the REDD+ area, some areas of the forest are healthy while others have been degraded (Ebinne et al., 2020). In the review of the literature, the REDD+ project has threatened the CRS forest communities by excluding them from decision-making and failed to meet their expectations (Krause et al., 2019; Isyaku, 2021; Nuesiri, 2016).

Krause et al. (2019) maintain that REDD+ had no significant impact on the livelihoods of forest communities in the CRS, Nigeria because they have not benefited from the program. Respondents indicate that financial incentives and access to natural resources would be a desirable benefit of forest protection in a study on the livelihood impact of REDD+ in the CRS by Amuyou et al. (2021). Furthermore, the role of income in influencing respondents' support for forest protection was emphasized. This implies that the local people will only protect forests if they are entitled to some benefit. In contrast to Amuyou et al. (2021) findings, Isyaku (2021) made some observations on the community motivation to participate in forest conservation in CRS. According to this author, community conservation is motivated by complex factors.

Therefore, monetary incentives may not always motivate people to participate in the REDD+ program. Based on the assessment of tropical deforestation and biodiversity loss in the CRS, Enuoh & Ogogo (2018) concluded that the government, private sector, and rural communities are jointly responsible for the alarming rate of tropical deforestation. One of the reasons deforestation abounds in the CRS was the approval of logging concessions in government forest reserves. Though there are forest policies, it has not addressed deforestation issues. It has been projected that by 2033, the CRS forests may be exhausted due to continuous deforestation. This may adversely affect the achievement of climate change goals and the sustainability of endemic primate species and the ecosystem in general.

Despite these shortcomings, not all the outcomes of REDD+ were negative. Drawing on the literature review and case studies analysis, the socio-economic benefit of the REDD+ project on local communities was highlighted. A small benefit of the program in three local communities in Nepal that are participating in REDD+ pilot projects was reported by Satyal et al. (2020). Although the study raised concerns about equitable sharing and social injustice, a few groups of people benefited from the program. Among the benefits delivered were cookery and weaving training, funding woollen carpet enterprises and ecotourism facilities, provision of biogas digesters and improved cooking stoves. A few traditional occupations were also installed.

Poudel et al. (2015) also noted that some marginalized and less privileged groups of people in local communities of Nepal were provided seed grants under the REDD+ benefits but the support was limited and insufficient compared to the losses they suffer. Lawlor et al. (2013) work also indicate that the REDD+ projects made a small positive contribution to the lives of local communities in a study conducted on forty-one REDD+ projects in Africa, Asia, and Central and South America. The benefits include direct payments, and indirect benefits such as infrastructure, job opportunities and assisting people to gain tenure rights. However, the benefit payment had a limited impact on household income, thus hindering poverty reduction.

Nevertheless, most projects are observing free, prior, and informed consent which is core to REDD+.

On the contrary, REDD+'s forestry programs neither provided any added value towards reducing deforestation nor provide agricultural and social benefits in Xmabén and La Mancolona, Mexico as evidenced in Špirić et al. (2021) study. The above narratives suggest that there are limitations in implementing REDD+. Additionally, challenges, benefits, deforestation rate, and the impact of REDD+ vary from country to country. Ezebilo (2012) argues that women and people with less income in rural areas depend more on forest products. Thus, the importance of considering local communities near protected areas when designing forestry projects like REDD+ and making them stakeholders has been emphasized. There may be a change in perception regarding forest and biodiversity conservation by so doing. Borokini et al. (2012) opined that the promotion of sustainable livelihoods may be a useful tool for reducing pressure on forests.

CHAPTER 4

This chapter covers the Spatio-temporal analysis and interpretation of the CRS forest change using the NOAA AVHRR annual mean NDVI.

4. Quantitative Data Analysis and Result: Forest cover change

This section evaluates the impact of the REDD+ program on forest cover in CRS using the annual mean Normalized Difference Vegetation Index (NDVI) time series. The mean NDVI was calculated using Zonal statistics in QGIS software. The year 2000 to 2009 represented pre-intervention, while 2010 to 2019 was considered post-intervention of REDD+. To determine the type of data analysis, a normal distribution test was carried out on the mean NDVI data using descriptive statistics. The result indicates that the data were normally distributed as skewness and kurtosis were within ±1. A normally distributed dataset is defined as having skewness and kurtosis between -1 and +1, according to Mishra et al. (2019). This suggests the use of a parametric test. Figures 5 and 6 depict how the NDVI data were obtained using zonal statistics calculations in QGIS. It is worth highlighting that the forest types were not separated in this study.

Descriptive statistics were calculated in Excel as follows;
Data → Data analysis → Descriptive statistics → Input range → Ok

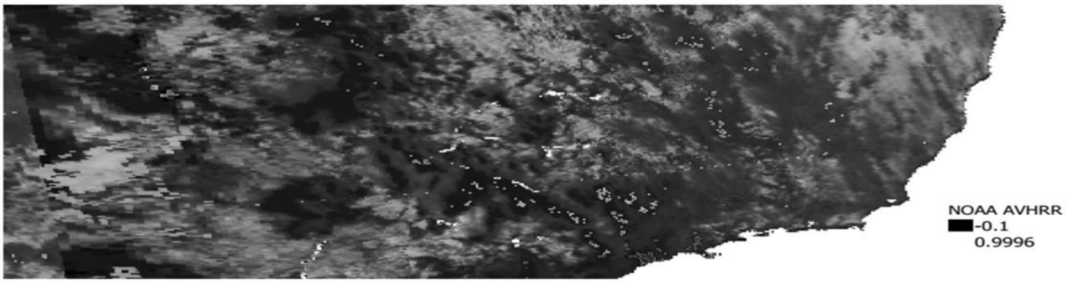

Image 1: NOAA AVHRR image before classification

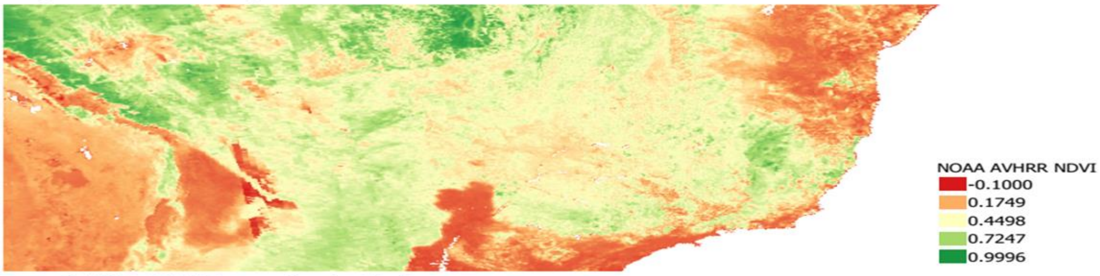

Image 2: NOAA AVHRR image after classification

Figure 5: NOAA ANHRR NDVI raster image before and after classification in Quantum Geographic Information System software.

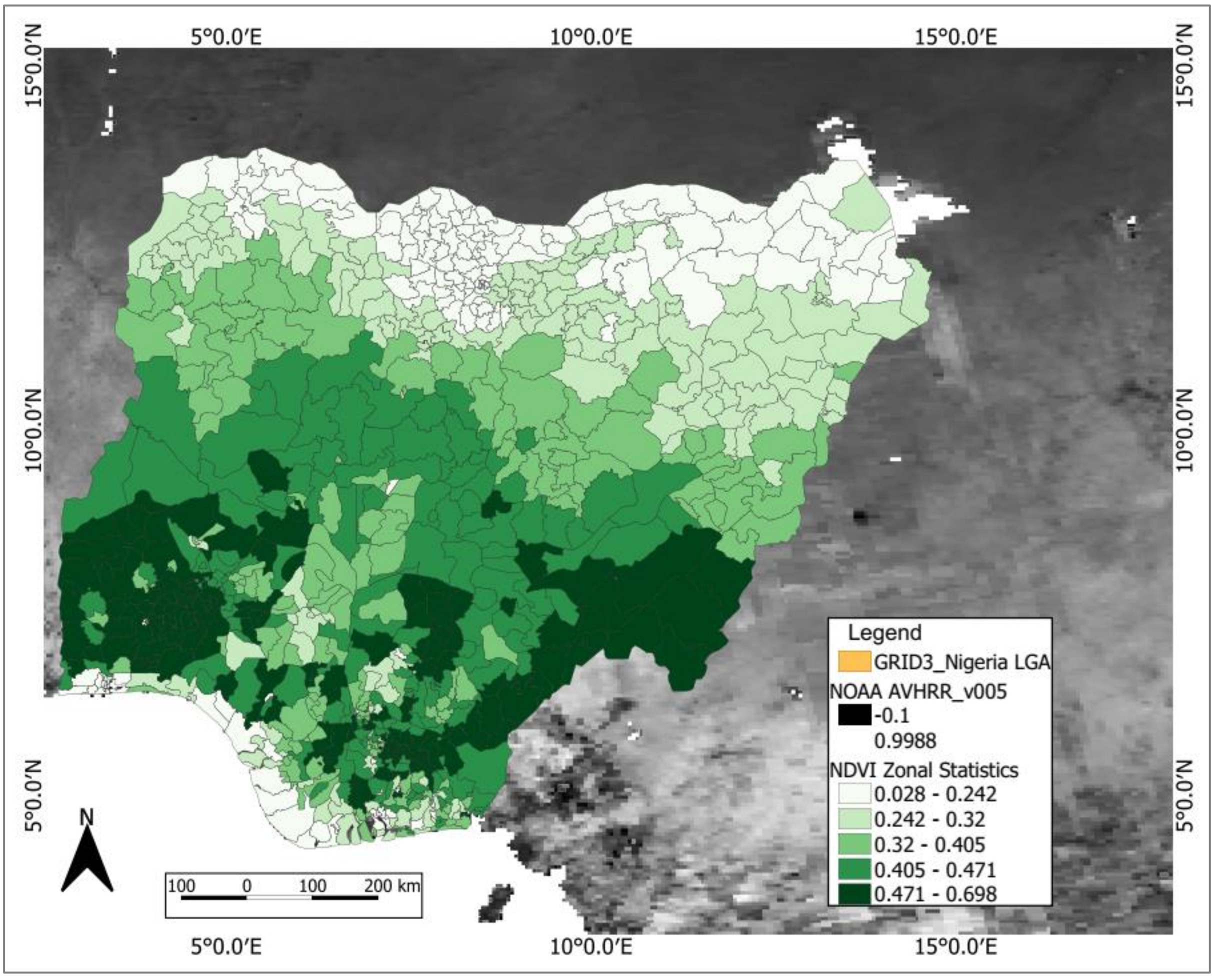

Figure 6: Image illustrates NDVI data extraction method for vegetation cover change analysis in Nigeria using zonal statistics in QGIS

Parametric t-test Analysis

Table 2: The parametric t-test result of the mean NDVI from the year 2010 to 2019 in Akamkpa LGA

Variable	Skewness	Mean	Std Dev	n	Df	t-Stat	P-value (one-tail)	P-value (two-tail)	t Critical value	
2000-2009	0.026	0.31	0.1274	307	601	3.46	<0.001	0.001	one-tail 1.647	two-tail 1.964
2010-2019	0.304	0.27	0.1260	296						

Table 3: The parametric t-test result of the mean NDVI from the year 2010 to 2019 in Boki LGA using a parametric t-test

Variable	Skewness	Mean	Std Dev	n	df	t Stat	P-value (one-tail)	P-value (two-tail)	t Critical value	
2000-2009	-0.384	0.41	0.142	307	601	2.46	0.007	0.014	one-tail 1.647	two-tail 1.964
2010-2019	0.157	0.39	0.145	296						

Tables 2 and 3 represent the parametric t-tests for Akamkpa and Boki LGA. The mean NDVI data from the year 2010 to 2019 was lower than that of 2000 to 2009 at both sites. The t-statistic for both study areas was bigger than the critical values. However, the p-value was less than 0.05 ($p<0.05$) at the level of significance. Therefore, the result suggests that the vegetation in the study areas was sufficiently impacted during the post-REDD+ intervention period.

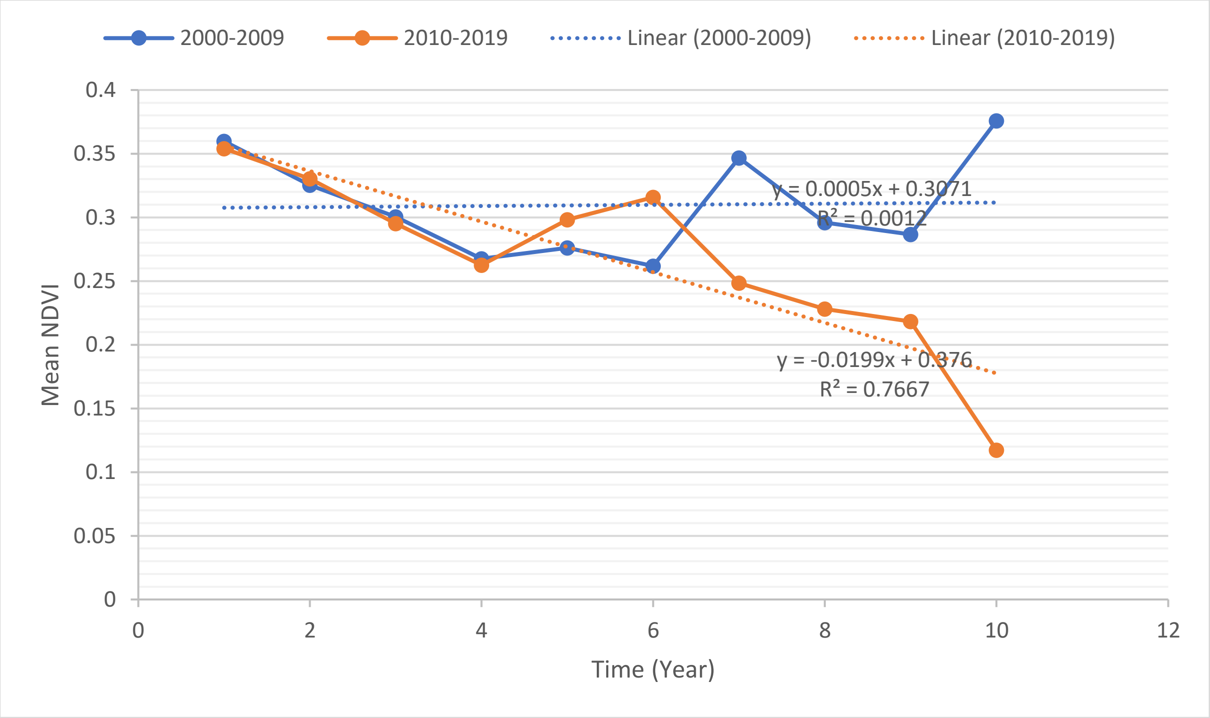

Figure 7: The historigram showing the trend of NDVI data from the year 2000 to 2019 in Akamkpa LGA

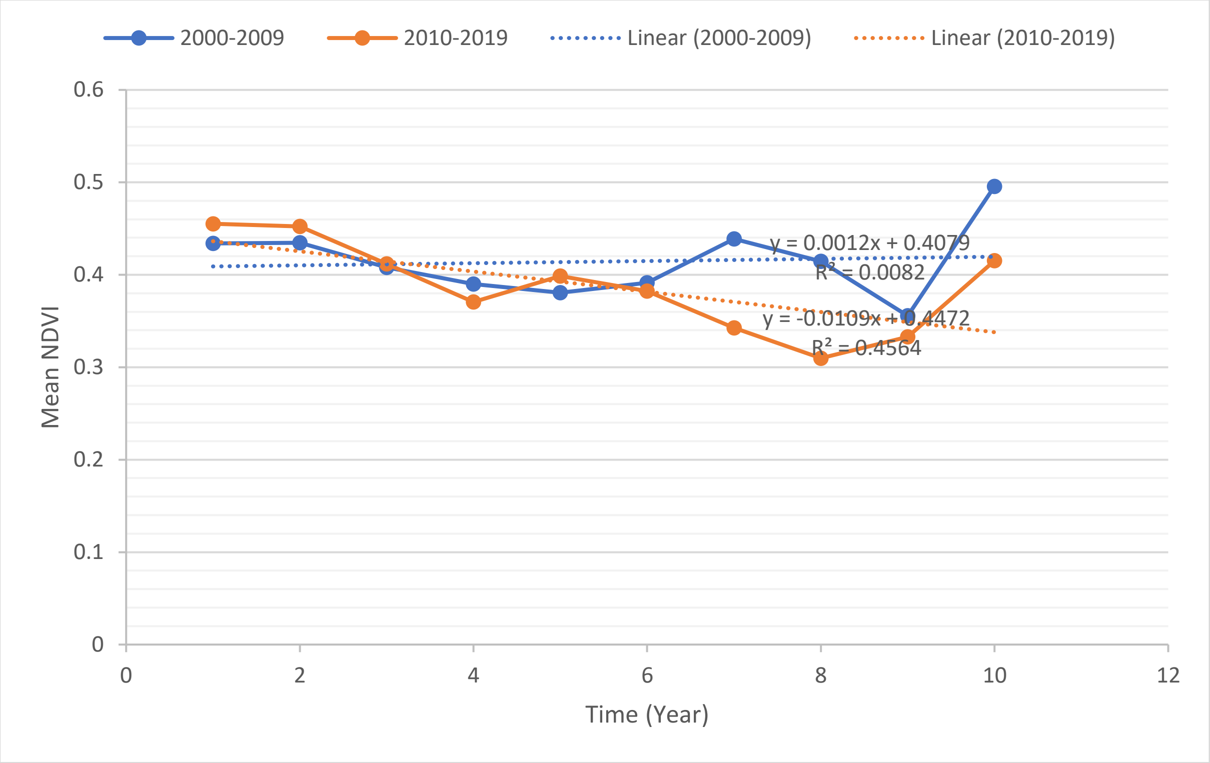

Figure 8: The historigram showing the trend of NDVI data from the year 2000 to 2019 in Boki LGA

Figure 7 and 8 above illustrates the historigram for Akamkpa and Boki LGA. A downward trend was noted. The trend in the mean NDVI of 2010-2019 was below that of the year 2000-2009 when compared. The trend was observed to be similar in both Akamkpa and Boki LGA. However, there appeared to be an increase in the year 2014 to 2015 at the Akamkpa LGA. Likewise, a slight increase was noted at Boki LGA in the year 2010, 2011 and 2014. However, the histogram result appeared to be fluctuating. According to the parametric t-test analysis, the vegetation cover has changed over time in Akamkpa and Boki local government areas.

In Tables 2 to 3, the mean NDVI in 2010-2019 (post-REDD+ intervention) were lower than in 2000-2009 (pre-REDD+ intervention). Likewise, the t-statistic for both study areas were bigger than the critical value in both the one-tail and two-tail test. However, the p-values range between 0.001 and 0.014 at a 0.05 level of significance ($p<0.05$). This suggests a vegetation cover increase in the study areas. Although the result indicates the vegetation change was significant, the preliminary analysis was insufficient to draw a comprehensive conclusion on the amount of change over time. Therefore, to ensure the credibility of the results and account for percentage variation in vegetation cover, simple linear regression and an independent sample t-test were carried out. The results were compared.

Time series analysis: ARIMA

Ordinary Least Squares (OLS) regression was carried out on the NDVI data. The autocorrelation function, partial correlation function and the Ljung-Box tests were used to check for autocorrelation in the model before running a regression.

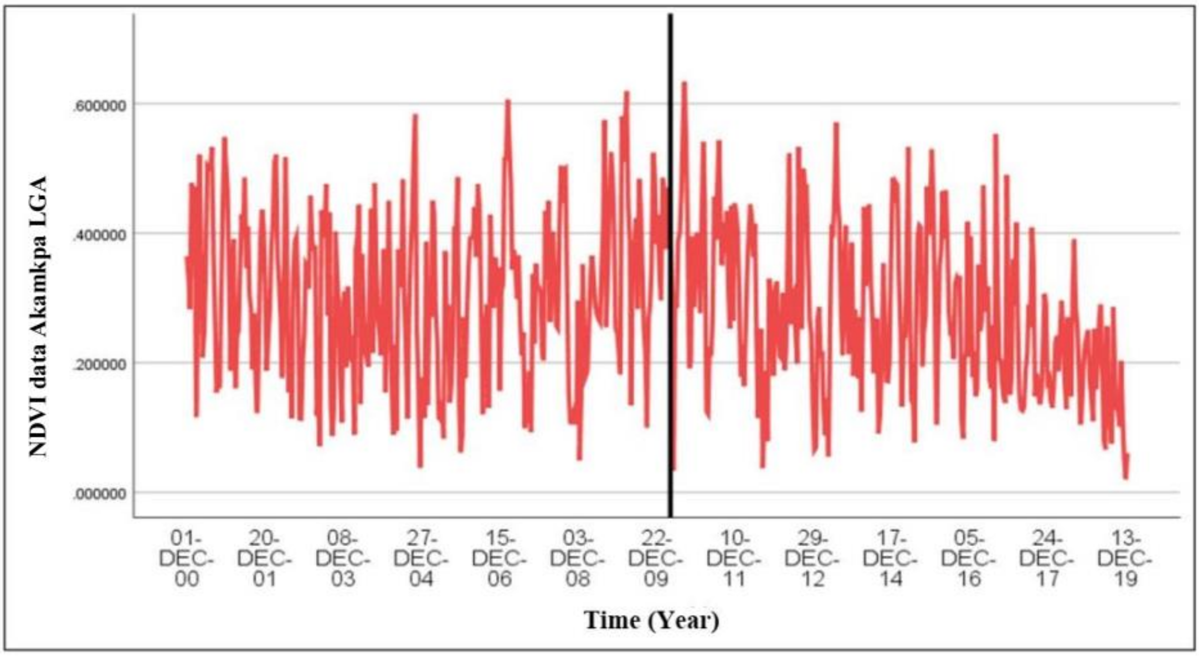

Figure 9: The mean NDVI time series graph of Akamkpa Local Government Area, Cross River State.

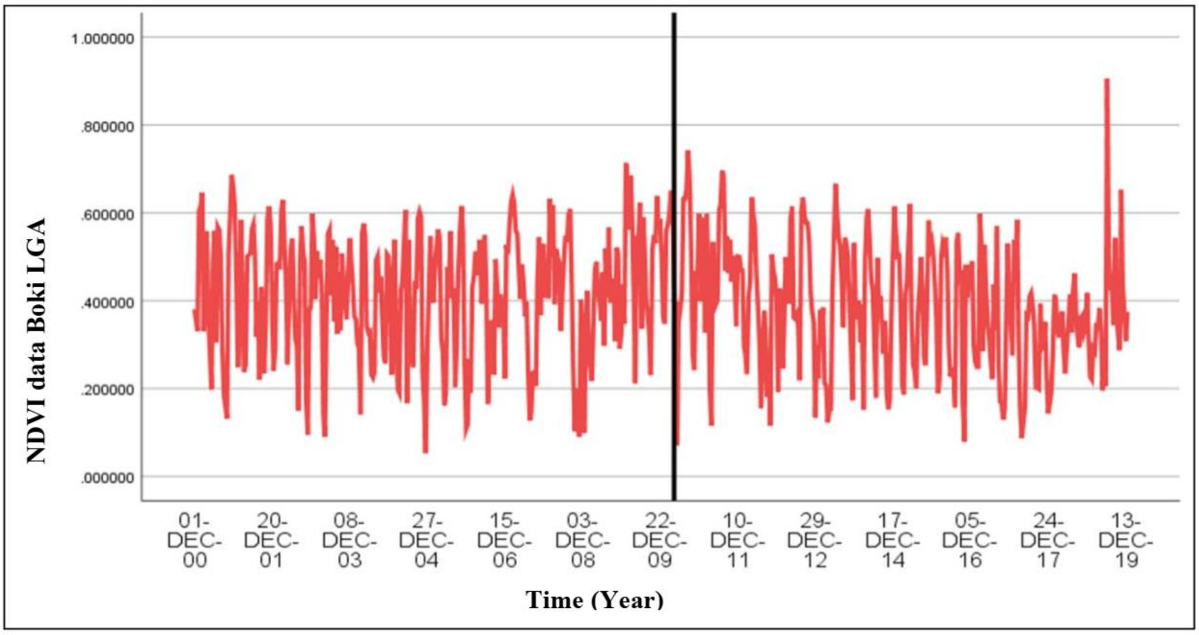

Figure 10: The mean NDVI time series graph of Boki Local Government Area, Cross River State.

Table 4: The descriptive statistics of the mean NDVI time series

	N	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Akamk#Pa	602	0.020629	0.633343	176.144862	0.29259944	0.127402198	0.016
Boki	602	0.052765	0.905187	241.091148	0.40048363	0.144130624	0.021

Figures 9 and 10 above represent the time-series graph of the NDVI data for the Akamkpa and Boki LGA. The vertical black line divides the pre-intervention of REDD+ from the post-intervention time series. In addition, this was done to monitor the oscillation difference in the two periods. The data showed that there was no consistent trend over the entire span. The data was stationary. Likewise, there were no apparent outliers as the square root of the variance was less than the mean of the NDVI for each Local Government Area. Based on these findings, it is difficult to tell if there is autocorrelation and if the variance was constant.

As a result, an autocorrelation function test (ACF), was carried out to determine the autocorrelation and the lag values in the time series. In addition, the partial autocorrelation function (PACF) was applied to the stationary time series data to look for signs of autocorrelation. According to Zoffoli et al. (2008), a sample (time series) ACF is usually accompanied by a PACF. The PACF measures the relationship between the value observed at month t: yt and the value observed at k months earlier: yt-k when the effects of other time lags (1, 2, …, k - 1) are removed. The real correlation between yt and yt-2 can only be determined when the effect of yt-1 is removed. A Ljung-Box test determines whether autocorrelations are present in residuals of fitted time series models or not (Lee, 2022). On the other hand, the goodness of fit (GOF) indicates how well a statistical model fits into a set of observations. The GOF summarizes the differences between the observed values and expected values under a statistical model (Maydeu-Olivares & Garcia-Forero, 2010). Furthermore, The Ljung-Box test is known to be robust for white noise detection (Burns, 2002; Alhamad et al., 2007; Mutti et al., 2020).

Thus, the Ljung-Box test was conducted in this study to verify if the residuals in the model act as white noise. The Akamkpa NDVI autocorrelation test result indicates there was no autocorrelation in the data series. However, it is noteworthy that the first and the seventh lag fall out of the control line (See Appendix 2). The p-value was not significant, even at a 0.05

level of significance, indicating no autocorrelation in the time series. For the Boki NDVI dataset, the test shows no autocorrelation as most data points fell within the control limit. However, as observed from the test, the first and the third lag fell out of the control line (See Appendix 2, figures 1 and 2). The p-value also appeared very non-significant, at a 0.05 level of significance. Following these observations, this study used a simple ARIMA (Autoregressive Integrated Moving Average) model to find the best fit for the pre-intervention analysis. However, the purpose was to account for the impact of the REDD+ intervention on vegetation.

This study draws an ARIMA model with intervention thus.

$Y_t = N_t + \sum f(I_t)$…….. Equation 1

Where Y_t = Time-series outcome measures at time t

N_t = The pre-intervention ARIMA model

$F(I_t)$ = Intervention function at time t

Table 5: The Model Fit analysis result for Akamkpa and Boki Models

Model	Number of Predictors	Model Fit Statistics		Ljung-Box Q			Number of Outliers
		Stationary R-squared	R-squared	Statistics	DF	Sig.	
AKAMKPA-Model 1	0	0.318	0.318	16.684	16	0.406	0
BOKI-Model 2	0	0.288	0.288	16.445	14	0.287	0
a. Best-Fitting Models according to R-squared (larger values indicate better fit).							

The time series regression for the pre-intervention dataset was run. The same data was used to predict the future trend of the data. Then, the forecasted values were compared to the post-intervention dataset. The difference reflected the impact of the intervention (REDD+). In Table 5, the ARIMA model test showed that time explained about 32% of the variation in the Akamkpa NDVI model. In comparison, time explained 29% of the vegetation variation in the Boki NDVI model. In other words, time accounts for 32% and 29% of vegetation change in both study sites. There was an absence of outliers in the dataset. That is, there were no extreme values. However, the result depicts that the current time was insufficient to give the best fit. Therefore, the ARIMA model was run through the lag periods to estimate the best-fit variables. In other words, the ARIMA model gave variables that fit the model. For Akamkpa LGA, the

NDVI before the current day was a significant predictor and the moving average before the seventh day was another reasonable predictor of the NDVI.

The parameter estimates were statistically significant at the 0.05 level of significance. Therefore, it explains that a change in the first lag period resulted in a 54% change in NDVI for Akamkpa LGA (see appendix 2, table 3). The Boki LGA NDVI lag one and two were reasonable predictors of NDVI. The parameters were statistically significant. It explained the changes in the dependent variable. Furthermore, the residuals were within the control limit set by the ACF analysis. Therefore, the model fitted the dataset for both Akamkpa and Boki LGA NDVI. This is based on the pre-REDD+ intervention period modelled and predicted for the post-REDD+ intervention. Afterwards, the forecasted data for the post-intervention period was compared to the actual data set for the post-intervention period.

The difference was computed and reflected in the residual data. The residual showed the impact (changes) during the intervention. As shown in figure 11 below, the forecasted data fell within the actual dataset for the post-intervention period for the Akamkpa LGA. It indicates that the major changes in the post-intervention period were not according to time. It could be attributed to factors outside time. A similar event was observed for Boki LGA. Figure 12 showed that the forecasted points fell within the post-intervention period's actual dataset. The above analysis suggests that there were changes in the vegetation cover over the intervention period.

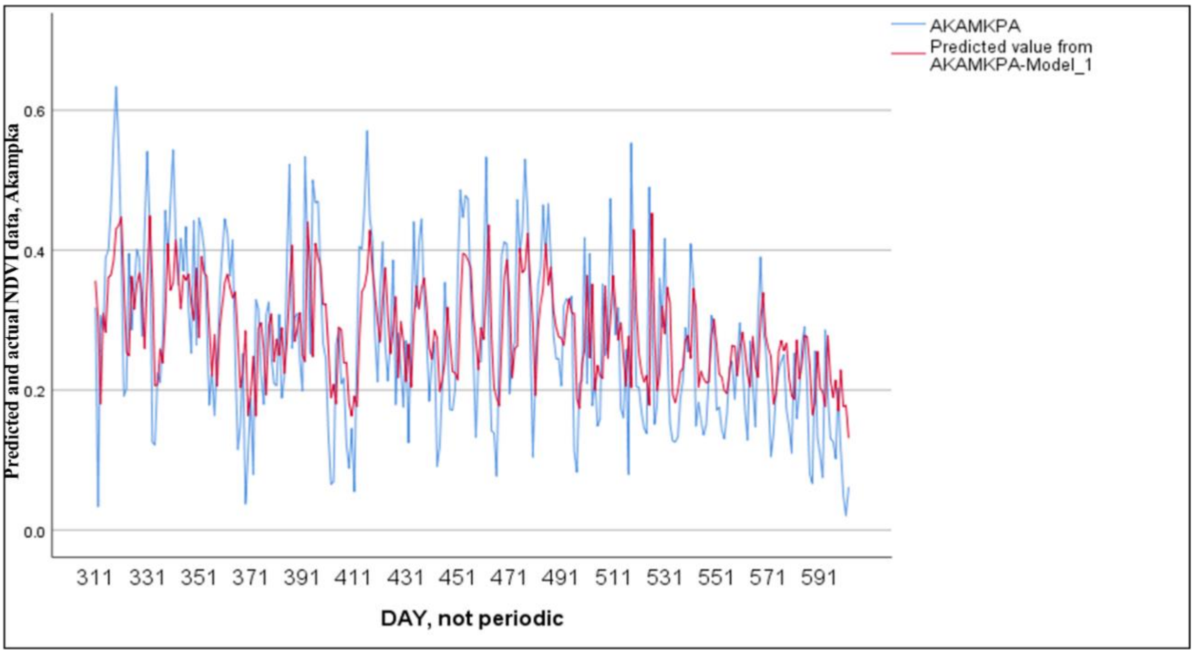

Figure 11: The REDD+ predicted and actual mean NDVI values of the post-intervention for Akamkpa Local Government Areas

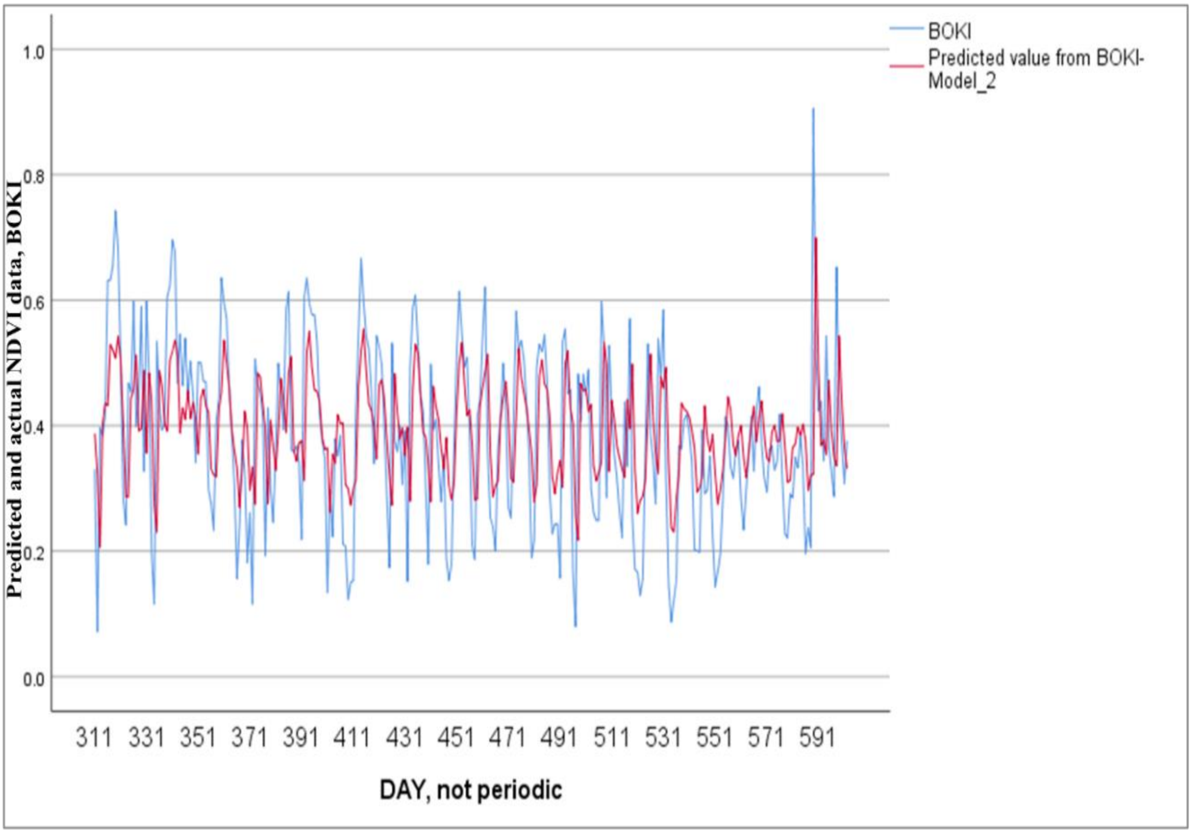

Figure 12: The REDD+ predicted and actual mean NDVI value of the post-intervention for Boki Local Government Areas

The residual values

The residual data (the difference between the actual and predicted values of the post-intervention period) was modelled against time to reflect the magnitude of impact during the REDD+ intervention. The residual curve showed constant variance and linear characteristics. Therefore, a simple linear model was used to depict the relationship with time. The residual data in figure 13 oscillated around the mean. It showed that the residual formed a pattern and proved neither non-linearity nor heteroscedasticity. In this case, this study considered a linear model for the intervention analysis. The descriptive statistics of the residual were computed as shown in Table 6. The residual for the impact of the intervention, when summed, showed a negative value for the two Local Governments (this study takes the absolute value). The mean of the impact (residual) was different from zero. To measure the magnitude of the impact during the intervention, a simple linear regression model of the residual was conducted.

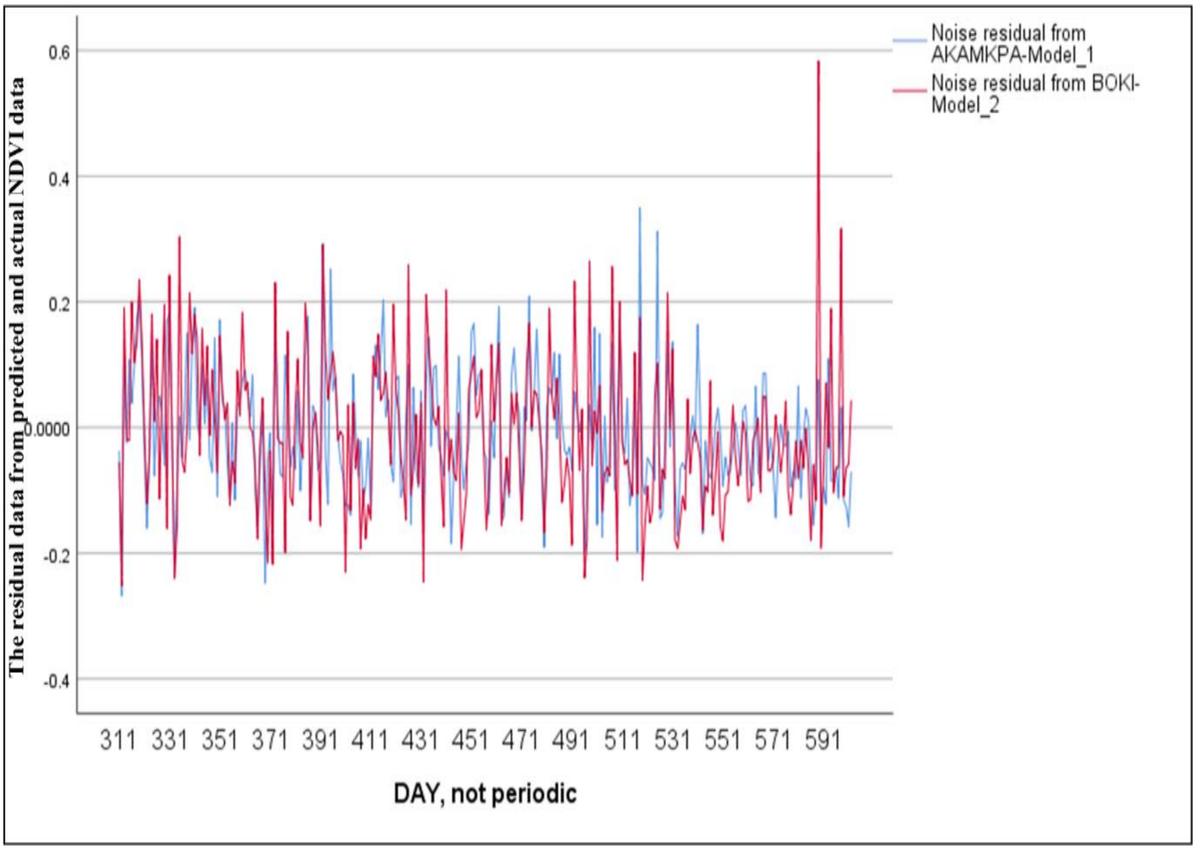

Figure 13: The residual data from the predicted and actual mean NDVI value of post-intervention for Akamkpa and Boki LGA, Cross River State.

Table 6: the descriptive statistics result of the residual data (predicted minus the actual data of the mean NDVI

Model	N	Sum	Mean	Std. Deviation	Variance
Noise residual from AKAMKPA (Model 1)	292	-2.498591	-0.00855682	0.101071393	0.010
Noise residual from BOKI (Model 2)	292	-2.983716	-0.01021820	0.121151462	0.015

Research Hypothesis

H_0: The REDD+ program does not improve the CRS forest cover.

H_1: The REDD + program improves the CRS forest cover.

Model

$Y_1 = b_0 + b_1 T \ldots\ldots\ldots$ Equation 2

$Y_2 = b_0 + b_1 T \ldots\ldots\ldots.$Equation 3

Where,

Y_1= Residual or the intervention in Akamkpa LGA

Y_2= Residual or the intervention in Boki LGA

T = time

B_0 = a constant term

B_1 = the rate of change or the parameter

The regression analysis for the two models is presented in Tables 7 and 8 above. The Durbin-Watson statistic shows that there was no autocorrelation in the data series. The result was significant at a 0.05 significance level ($p<0.05$). Therefore, the result suggested that the vegetation in the study areas was sufficiently impacted during the REDD+ intervention. In other words, the program may have had a slight positive change on the forests. For Akamkpa and Boki LGA, time (T) explained a 3.5% variation in the model. Therefore, any other major changes that may have occurred during the post-intervention of REDD+ in the CRS can be attributed to other factors. However, more variables could be added to this study to improve the model and identify the major drivers explaining variations in vegetation gain.

Table 7: The OLS regression analysis result for the post-intervention in Akamkpa LGA

Model	R-Square	Sig F Change	Durbin-Watson	Unstandardized Coefficient B	T	Sig.
1	0.035	0.001	1.991	0.093	2.905	0.004
DAY, not Periodic				0.000	-3.225	0.001
Note: a. Predictors: Constant, DAY, not periodic						
b. Dependent Variable: Noise residual from Akamkpa Model 1						

Table 8: The OLS regression analysis result for the post-intervention in Boki LGA

Model	R-Square	Sig F Change	Durbin-Watson	Unstandardised Coefficient B	T	Sig.
2	0.035	0.001	2.070	0.093	2.915	0.004
DAY, not Periodic				0.000	-3.225	0.001
Note: a. Predictors: Constant, DAY, not periodic						
b. Dependent Variable: Noise residual from Boki Model 2						

Hypothesis decision

The linear regression of the NDVI data for Akamkpa and Boki LGA from 2000 to 2019 showed that there was a significant difference in the vegetation cover ($p<0.05$). Therefore, this study rejected the null and accepted the alternative hypothesis. The forests were sufficiently impacted positively during the REDD+ intervention period.

Independent Sample t-test

An independent sample t-test was also conducted to examine the NDVI data further. Independent samples t-test is used to find out whether there is a statistically significant difference between the mean scores of two groups whose mean are independent of one another. Two samples are considered independent if the sample values selected from one population do not relate or are somehow paired with those selected from the other population (Gerald, 2018; Xu et al., 2017).

Table 9: The independent sample t-test group statistics of the mean NDVI data

	Pre_intervention=0 Post_intervention=1	N	Mean	Std. Deviation	Std. Error Mean
AKAMKPA	0	292	0.311	0.128	0.007
	1	292	0.273	0.124	0.007
BOKI	0	292	0.416	0.143	0.008
	1	292	0.384	0.144	0.008

Table 10: The independent Sample t-test result of the mean NDVI data for Akamkpa and Boki Local Government Area

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
AKAMKPA	Equal variances assumed	0.333	0.564	3.682	600	0.000	0.038	0.010	0.018	0.058
	Equal variances not assumed			3.685	599.212	0.000	0.038	0.010	0.018	0.058
BOKI	Equal variances assumed	0.097	0.756	2.740	600	0.006	0.032	0.011	0.009	0.055
	Equal variances not assumed			2.739	596.969	0.006	0.032	0.012	0.009	0.055

The independent sample t-test result for the Akamkpa LGA in figures 9 and 10 indicates that there was a significant difference in vegetation cover. The p-value was less than 0.05 ($p<0.05$). Thus, the null hypothesis was rejected. However, the mean (0.311) of the pre-REDD+ intervention was significantly higher than the post-REDD+ intervention mean (0.27). The estimated mean difference was 0.038. Nevertheless, the hypothesis decision was made based on the p-Value.

Similarly, for Boki LGA, the p-value was less than the significance level of 0.05. The null hypothesis was rejected. The mean value of the pre-REDD+ intervention NDVI was 0.42, while that of the post-REDD+ intervention was 0.38. The estimated mean difference was 0.032. This implies that the mean value in the pre-intervention period was significantly higher than the mean of the post-intervention. However, the result was based on the p-value ($p<0.05$). rather than the mean values. Therefore, the alternative hypothesis was accepted.

Hypothesis decision

Figures 9 and 10 show the independent sample t-test for the NDVI data at Akamkpa and Boki LGA, Cross river state, from 2000 to 2019. The result suggests that the REDD+ program may have had a positive effect on the vegetation cover. The p-value was less at a 0.05 level of significance. Therefore, the null hypothesis was rejected and the alternative was accepted. The forests were sufficiently impacted during the REDD+ intervention period.

CHAPTER 5

5. Key informant and Survey Results

This section discussed some of the findings from the interview related to the REDD+ outcome in CRS. The remaining interview result is presented in the discussion because it explains the possible reasons for forest loss in CRS. The interview involved eight key informants; a village elder, four forest officers and three eco-guards. They were among the CRS's forest security and monitoring team. For easy communication, the word eco-guard was used in this study. In this chapter, the REDD+ benefit was evaluated and discussed based on capacity building, skill acquisition, direct cash payments, infrastructure development and credit access.

Interview Result

Achievement: Benefit of REDD+ to forest guards

The benefit of REDD+ in the CRS forest communities to the guards and their community was investigated. According to the information obtained from the interview, some level of attention was paid to human capital at the initial stage of the REDD+ program. Few women and men were trained in entrepreneurial skills to support their livelihood. Likewise, REDD+ gave small grants to eco-guards. However, the grant was not in cash. Cassava grinders were bought for eco-guards as an incentive because they were not paid a salary. This implies that some villagers were trained to develop their businesses which may eventually translate into an additional income. However, there was no reference to financial capital such as a loan. Similarly, physical capital was not mentioned during the interview.

"REDD came in with a good start; some women and men across the state who embraced this idea were trained on raising mushrooms, snailry and bee farming" (eco-guard 1).

"REDD+ gave a small grant to people, but the grant was not in cash. They gave cassava grinders to the eco-guards as an incentive because they were not being paid (village elder).

On the contrary, the rest of the respondents maintain that nothing significant has been achieved under the REDD+ program. Therefore, they could not give an account of other community's benefits from the REDD+ program. They believe that the details of the achievement thus far lie with the REDD+’s office and the CRS government. A sense of disappointment was also noted during the interview.

> “*As REDD+ is concerned, there is no impact on it because we are not seeing anything. If I have the opportunity, I will tell the people in charge to come and snatch it away from the Cross River State government" (eco-guard 5).*

Livelihood concerns

The interview result suggests that some people in the forest communities were aware of the REDD+ program when it started in the CRS. They embraced the idea and the government’s policy. However, the initial support seemed to have been lost, and people drifted away from the conservation concept over time due to their initial perception that REDD+ would provide or improve their livelihood. Although some people received livelihood training as stated earlier. Respondents claimed that the CRS government promised them entrepreneurship skills and financial assistance to start-up businesses but failed to fulfil their promises. The villagers felt disappointed when this was not forthcoming. They also stopped granting royalties to forest communities and this caused resentment toward the government.

The forest communities in the time past received royalty, however, this was stopped after the CRS logging ban. Consequently. the villagers uproot planted trees because they felt their perceptions were unconsidered and the government did not meet their demands. Whenever they were approached while carrying out any degradation activities, they did not listen. This indicates a defiant attitude towards the government that might not even solve the livelihood problems of the villagers. The finding corroborated with those of Asiyanbi (2016) and Isyaku (2017) who report that the cancellation of royalties from timber revenue in the CRS led to conflict.

> *"The forest would have increased, but the villagers will uproot anytime we plant trees. In our office, we have tree seedlings, but do we plant them? When we challenged the villagers while cutting trees, they asked, this forest was reserved for who? We are the posterity, taking what belongs to us" (eco-guard 1).*

> *"If you tell people not to touch what is sustaining them, you have to provide an alternative, if not, they will not save the forest. If the government support the communities, they will give you their very best" (eco-guard 2).*

Questionnaire Result

Distribution According to the Years of Residence of the Respondents

This section indicates the length of years the individual respondents had resided in their respective communities. It varied from a year to 50 years. Across the communities, the highest number of years that the majority had spent was between 11 to 20 years (26%), followed by 21 to 30 years (21%). Some people have also stayed for over forty years.

Distribution According to the gender and marital status of respondents

The gender of the respondents showed how they spread across the two gender groups. In all the communities that were sampled, the population of male respondents outnumbered the female. For instance, in the Owai community, 64.5% were male, in the Buanchor community, 66.7% were male, the Iko-Esai community had 75% males, and Kanyang 2 community had 71.4%. Also, the Abo community has 92.6%, while the Ekuri community has 63% male respondents in their community. The total number of male respondents was one hundred and fifteen, while the number of females was 45. This represents 72% and 28% respectively. Likewise, the number of married respondents was higher than the number of unmarried respondents in all communities. A very small number of divorced and widowed respondents were found in the Owai, Buanchor, and Ekuri communities. In total, married respondents were 61%, while single respondents were 35%.

Distribution According to the Age of Respondents

Figure 14 illustrates the age brackets of the respondents from the individual forest communities. The percentage of people across the six communities between the age of 21-30 years, when summed, was higher than any other age group except in the Owai community. Aged 21-30 were 60 respondents (38%), 31-40 years were 47 people (29%) and 41-50 years were 27 (17%). Aged 61-60 were 18 people, while aged 61-70 were seven respondents. This represented 11% and 4% of the sample size, respectively. A respondent in the Ekuri community did not indicate an age group, and it represents 3.7% of the sample for the community. This implies that many of the respondents were young people. However, age might not influence community participation in forest conservation. Nevertheless, all age brackets in a community should be encouraged to participate as noted by Enamhe & Okang (2019).

Gender distribution of the respondents

Marital status of the Respondents

Age (year) distribution of the respondents

Number of children of the respondents

Distribution according to head of the family

Households size of the respondents

Households major occupation

Households annual income

Respondents year of residence

Distribution of respondents farm possession and size

Farm size rented out by respondents

Farm size rented in by respondents

Figure 14: The demographic result for Akamkpa and Boki Local government Area, Cross River State.

Distribution of respondents based on the head of the family, number of children and Household Size

The demography results showed that many respondents in the sample were the heads of their families, as the overall percentage was above 60%, except in the Buanchor community which has 40%. In clear terms, Kanyang 2 community has a larger portion of its respondents as the heads of families (81%). In the Owai community, 67.7% of the sample size were the heads of their family, Iko-Esai community has 75%, Abu community 70.4%. Lastly, the data from the Ekuri community showed that 66.7% were the heads of their families. In each community, most respondents had at least one to five children (50% and above). Although some respondents had between six to ten children, they were below 30% in all the communities. Furthermore, some respondents did not indicate whether they had children or not. They represent 12.9%, 30%, 16.6%, 23.8%, 14.8 and 14.8%, in Owai, Buanchor, Iko-Esai, Kanyang 2, Abu and Ekuri respectively. Similarly, across the six communities, households with six to ten (6-10) members were high (42%), while households with 1-5 members were 35%. There were also households with more than ten members, and they represent approximately 11% of the sampled population across the communities. There were situations where respondents did not indicate the number of households because they were still single.

Distribution of the respondents according to major occupation, farm size and annual income

Furthermore, the result in figure 14 showed that farming was the principal occupation of the six communities (above 70%). They were mainly engaged in crop farming. Out of the 160 respondents, only one person was into livestock farming. In the Owai community, 96.8% were farmers. 73.3% in Buanchor, 91.7% in the Iko-Esai community, 90.5% in Kanyang 2 community, 81.5% in the Abo community and 85.2 % in Ekuri community were farmers. It was observed that other respondents engaged in a non-farm occupation. For example, seven respondents (4%) were civil servants, eight respondents (5%) were into other types of occupation, and three respondents did not indicate their occupation. Furthermore, the result suggests that most respondents (71%) possessed farmlands of different sizes ranging from plots to hectares. Some respondents (9%) rent out their farms to other farmers, while others (6%) rent farms to cultivate their crops. Moreover, 67% desired more land for agricultural purposes as against other forest resources.

The annual income of respondents for this study was estimated. Respondents earned different incomes annually to care for their families and personal needs. The highest number of earners (24%) was between two to three hundred thousand Naira (₦201,000-₦300,000) annually. Similarly, 24% also earned five hundred thousand to two million Naira (₦500,000 - ₦2,000,000). This represented $481-$720 and $1,201- $4,805. However, a reasonable number of the respondents (30%) earned between ₦ 10,000 and 100,000 ($25 - $240) per annum as of the time of this study.

Figure 15: The percentage of respondents who were aware of the REDD+ and climate change in Akamkpa and Boki Local government Area, Cross River State.

Assessment of forest conservation, REDD+, climate change awareness and understanding

Figure 15 demonstrates that over 60% of respondents understood the concept. However, the Ekuri community appeared to better understand by choosing the option that best captured the forest conservation definition. In each of the six communities, 93.5%, 60%, 95.8%, 57.1%, 88.9% and 70.4% said they had received conservation awareness. Furthermore, 81% of respondents across the communities believed that their forest should be conserved, and only 5% were not in support. This result suggests that most respondents knew what forest conservation meant. In this study, the assessment of awareness of the REDD+ program tailored to combat climate change impact was examined in the CRS. The result is presented in figure 15. The result suggested that some villagers were aware of the existence of the REDD+ program (43%). Fifty-seven percent of respondents were oblivion of it.

This indicates that the number of respondents that were not aware of the REDD+ program and its meaning was more than those that had heard about it. In support of the preceding point, many respondents did not understand what the REDD+ program represented. Fifty-two respondents (52%) did not respond to the question, while others could answer the question. However, some respondents already participated in the REDD+ program (25% of the sample size). Nevertheless, 71% of respondents confirmed that they had not been invited to participate in the REDD+ program. Furthermore, those involved worked in the awareness and monitoring team and as forest protection guards. In addition, some respondents were active in forest management and conservation program. Likewise, many respondents (44%) expressed that they would like to participate in the REDD+ program.

Livelihood, support, and benefit-sharing of REDD+ in CRS forest communities

Figure 16 presents the outcome of the benefits of the REDD+ assessment. A substantial number of respondents (94.4%) had not received any personal compensation. Nine respondents (6%) stated that they were compensated by cash and other means. Furthermore, it was observed that many respondents (86%) across the forest communities used the forest as their source of income and means of livelihood. They carried out activities such as farming, hunting, and logging. Fifty-seven percent did not have another type of livelihood apart from farming while 42.5% had. Furthermore, the result indicates that these communities experienced diverse levels of restrictions in accessing the forest. Forty-seven percent of the sample population stated that they were restricted from using the forest, while 46% claimed they were not. However, 7% did not indicate their choice. As illustrated in figure 16, most respondents (71%) possessed farmlands of different sizes. This implies that many of them had access to land for agricultural purposes. Conversely, access to credit facilities under the REDD+ program was not encouraging. Only three (3) respondents in two forest communities attest to have secured a loan for a business opportunity. This constituted approximately 2% of the sample size. It appeared that many could not secure a loan through the REDD+ program. However, further research is needed in this area.

According to Satish (2007), rural communities need infrastructure to enhance their quality of life and economic activities. In line with this. In all six communities, 19% of respondents claimed to have received infrastructure. There is a probability that some infrastructures were provided. However, 81% of respondents did not indicate their position. They were unaware of the infrastructure benefit the REDD+ has provided them. Over 70% of respondents in each forest community confirmed the presence of social groups. They claimed that they shared vital information among themselves to enhance forest conservation. Furthermore, some respondents (23%) stated that they were supported and empowered in their effort to reach a wider audience in their communities. Skill acquisition and training were examined as they may improve participation in forest management as Mazur and Stakhanov (2008) noted.

Training and skill acquisition

Respondents were asked if they had received any previous training or skills in their community. This was different from the REDD+ compensation question. The result showed that forty-two respondents (26%) had received skills/training. However, one hundred and eight (74%) respondents said that they had not received any skills or training that could support their livelihood. Respondents received training in agriculture-related areas such as cocoa, crops, fish, and vegetable farming. Very few people were trained in plumbing, catering, fertilizer making, eco-guarding, and forest management. It is important to highlight that only one respondent declared to have received skill acquisition training when questioned on how the REDD+ program compensated them. This implies that the training received was outside of REDD+. Respondents mentioned the areas they would like to receive training if they were to be trained for livelihood improvement. The areas recommended were crop improvement, farm tools usage, cocoa, livestock, catfish, snail, and poultry farming. Only four respondents selected other professions such as catering, fashion design and healthcare assistant.

Do you use the forest as a source of income?

If yes, what activity do you carry out in the forest?

Are restricted from using the forest?

Do you have an alternative livelihood?

Have you ever been compensated under the REDD+ program?

If yes, how were you compensated?

Have you received credit for a business?

Have you received alternative livelihood training/skill ?

Type of infrastructure received

Do you have forest conservation group in your community?

Do you share information among yourselves?

Are you empowered by REDD+ in your social grpup?

Figure 16: The percentage of respondents that benefited from the REDD+ program in Akamkpa and Boki Local government Area, Cross River State.

REDD+ and the forest community: Conflict, migration, and expectations

According to this study, the cause of timber extraction was building purpose, business, poverty, unemployment, hunger, and the government's carefree attitude towards the forest community. Multiple responses were obtained on the government’s efforts regarding forest conservation and the REDD+ in CRS program. As shown in figure 17, many respondents (41%) were displeased with the program, while a few (23%) were in support. However, 36% of the respondents did not indicate their point of view. Most of the respondents (80%) agreed that their forest should be conserved in the CRS while nine (5%) respondents were not in support. On the contrary, twenty-two (14%) respondents did not indicate their position on the matter. The above response means that most respondents were in support of forest conservation in their communities. Despite that, it appears many were not in support of the government being in charge of forest conservation tasks. Furthermore, seventeen respondents (11%) across the communities affirmed that they were allowed to collect timber or Non-Timber Forest Products (NTFPs) from the forest.

In comparison, one hundred and eighteen respondents (74%) stated that they were not allowed to collect timber or NTFPs from the forest in their community. However, twenty-five (15%) respondents did not indicate their opinion. It implies that a larger proportion of people were not allowed to gain access to forest resources. This was a conflicting response, and there was a high probability that accesses to forest resources differed in the forest communities. Furthermore, a question was asked about the protocol for collecting NTFPs. One hundred and forty-five respondents (90%) across the communities did not indicate their opinion. Nine (6%) respondents affirmed that there were protocols to follow in collecting timber or NTFPs from the forest reserve, while six (4%) respondents maintained that there were no protocols. However, if there were protocols, it seems many respondents were not following the rules because only 4% attests to doing so.

Moreover, respondents were asked to identify the factors that could motivate them to participate in forest conservation in their communities, as well as what they expected from the government. The factors suggested were government recognition of local people in their fight against deforestation, provision of security for forestry workers, effective collaboration between the government and the community, community empowerment and community-based forest management. This response suggests that the forest communities would like to manage their forest themselves. Other factors mentioned were government sincerity, good governance, basic infrastructure, employment, incentives, skill acquisition, financial support for businesses, expansion of cocoa production for export, creation of alternative livelihood, and training of forest guards to protect the forest. On the other hand, one respondent made it known that the government had failed them and as such, there were no expectations.

Lastly, respondents were asked if they would be willing to migrate from the forest reserve areas to other parts of the CRS as a requisite for conservation. Figure 17 illustrates the responses and opinions of the villagers. Over the six communities, 31% of respondents predicted they might migrate within a few years, and 12% said they might migrate. Conversely, 46% of respondents affirmed that they would not migrate from the forest areas. In comparison, 11% of respondents did not indicate their interest. Therefore, the result suggests that most respondents might not be willing to move away from the forest areas. Respondents expressed that they desire to have access to land, timber, and firewood. This may negatively affect forest conservation in the future in the CRS as the population increases. Thus, better insight is needed to deal with this challenge.


Are you allowed to collect timber/NTFPs?

Is there a protocol in collecting NTFPS by the villagers?

Observing protocol for NTFPs collection by respondents

Type of resource(s) desired by respondents

Would you like to participate in the REDD+ program?

Should the forests be conserved?

Resondents willingness to migrate from forest areas

Respondents satisfaction with forest conservation through REDD+

Figure 17: The percentage of respondents that were satisfied with the REDD+ program, migration and the cause of conflict in Akamkpa and Boki Local government Area, CRS.

CHAPTER 6

6. Discussion, Conclusion, and Policy Recommendations

6.1. Discussion

6.1.1. Forest cover loss and challenges in the CRS

Forests are an important element of REDD+ because they are necessary to achieve the program's goals. In other words, forests are the primary foundation upon which REDD+ was built for forest-based climate change mitigation. Forest change can be attributed to a variety of factors and results from either forest loss or gain. The delivery of ecosystem services can be affected by these changes (Min-Venditti et al., 2017). In addition to land use and forest fires (Hansen et al., 2013), urban expansion, economic, and social factors contribute to forest loss (Drummond et al., 2010). On the other hand, conservation, forest regeneration, reforestation, and afforestation programs can contribute to forest growth. Jiang et al. (2021), Lin et al. (2020), Liu et al. (2015) and Zhang et al. (2016) argue that these types of programs can influence the greening trend measured by the NDVI as the vegetation cover changes.

Through interviews, this study sought people's opinions about the impact of REDD+ on the CRS forest to compare it with the quantitative NDVI result. Several challenges that may have contributed to forest cover loss were identified. The interviewees unanimously assert that the CRS forests were decreasing because most forests that were supposed to be intact were under degradation. According to the respondents, timber dealers built ad hoc roads to harvest trees in villages and tree logging was witnessed daily. It is worth highlighting that there was a logging ban in the CRS for forest conservation and the REDD+ program as noted by Asiyanbi (2016) and Krause et al. (2019). However, it appears that the rule was less effective when it comes to income-generation activities in the CRS forest communities.

This study finding is consistent with earlier work by Ambe & Obeten (2020), Alu (2021) and Alobi et al. (2020) who maintain that the logging ban in the CRS has not reduced illegal timber exploitation in the state. Concerns were raised by respondents over the current deforestation rate in the CRS. There was an assumption by an eco-guard that the situation became worse at the advent of the REDD+ program. The deforestation was blamed on the logging ban and the

CRS government for failing to meet the forest communities' demands. This corroborates with Krause et al. (2019) who observed a similar finding.

> *"We cannot say that the forest is increasing because there is much logging going on, especially where REED+ sites are not situated across the CRS. Although, nature will also take its cause such as trees falling on their own" (eco-guard 5).*

In contrast, one of the respondents (village elder) believed that the forest had increased because they were involved in tree planting and forest regeneration programs, and people were planting trees in the CRS more often than before. The assumption was probably based on the annual tree planting in the CRS, which is arguably ceremonial rather than the actual reforestation or afforestation program as stated by Fon et al. (2014). Nevertheless, it is likely that such a program was ongoing within the CRS probably with the help of the REDD+ program at the time of this study. This may have impacted the NDVI positively. The narratives above present a notion that people have different opinions regarding the current situation of the CRS forests that are not quantifiable. This may affect conservation goals.

> *"I think the forest is increasing because there are some policies in the state that if you cut one, you plant 20 trees, and people started planting. However, we realize that the government is not doing too well in planting, but they are the ones taking the benefits" (village elder).*

It is worth emphasizing, however, that the qualitative finding of this study was not consistent with the quantitative result. In the CRS, logging seems to be occurring based on the key informant interviews. In chapter 4, the forest cover change analysis using NDVI indicates a slight but significant positive impact ($p<0.05$). Time accounted for a 3.5% vegetation variation during the REDD+ program year. This suggests that the REDD+, social capital or any other REDD+-like program in the CRS may have improved the forests or vegetation cover at the study locations. This improvement may lead to carbon emissions reduction and preservation of the CRS biodiversity. However, vegetation change was accounted for using one variable (time).

Several other variables that affect forests were not considered due to a lack of data. Adding these variables would have improved the model and identified the major drivers explaining the variations in vegetation gain. It would have also provided a more comprehensive understanding of the REDD+ program's overall impact. It is noteworthy that the forest reserves were not visited because it was beyond the scope of this study. Therefore, the result is subject to investigation of actual and observable ground activities capable of impacting forests and NDVI positively. There is a need for further research to know the level of protection against logging activities in the local government areas where REDD+ is situated. It is also necessary to find out whether there are reforestation or afforestation programs, when they were initiated and where they are being implemented in the CRS. This may explain the major drivers of vegetation gain in the study area.

Violent timber extraction is one of the factors that may have prevented adequate forest protection that led to forest loss in the CRS. The interview revealed that most of the people involved in the logging business were armed with weapons and posed a threat to anyone that tried to stop them. Consequently, the eco-guards were unable to effectively prevent further deforestation in CRS. In some areas of CRS timber dealers sometimes cut trees without too many interruptions according to the report. Additionally, when culprits were arrested and taken to the police station, they bailed themselves out. To this end, the eco-guards became careful in dealing with the matter because they still go to the same community to work. Furthermore, the people involved in forestry operations, including the law enforcement officers that were supposed to help fight illegal logging were reported to have ignored the issue and excluded themselves from the situation. Thus, the culture of forest degradation could not be fully curtailed. This slightly suggests that logging activities may still be ongoing in the CRS.

> *"It is difficult for us as eco-guards and forest officers to stop the loggers because they are armed with weapons and are deadly. In our office, how many arms do we have? We are not armed; how do we go to the forest to apprehend people and come out?" (eco-guard 2 and 5).*

This supports Anugwa et al. (2022) who reported that illegal timber dealers reinforced and arm themselves with weapons against security personnel and forest guards that attempt to prevent them from invading protected and reserved forests in the CRS. Likewise, Ikuomola et al. (2016) found a similar problem in another political region of Nigeria (southwest). This indicates that the issue extends beyond Cross River State, Nigeria. The use of forest guards and rangers in forest patrol, rule enforcement, and community activities monitoring in conservation projects such as REDD+ is well documented in the literature. Governments and conservation authorities set them up mainly to achieve maximum conservation results. In any case, violence between these law enforcement agents and the villagers has been reported, especially where the forest community perceives this to be a threat to their livelihood. Sometimes the guards are left to themselves to fight against armed loggers. Additionally, studies have found guards receive little financial incentive\support. In other circumstances, they were told to work for resources of the common as a volunteer. Consequently, they are unable to perform their duties effectively (Banana & Gombya-Ssembajjwe, 2000; Robinson et al., 2010; Rahman and Miah, 2017; Hayes and Persha, 2010; Setyowati, 2020).

Still, on the preceding point, this study also found that the CRS eco-guards were not paid salaries. Apart from this, many of them are farmers and had to work for a living. The line of argument was that the eco-guards fend for their families and need to generate income from other activities. Although the eco-guards were said to have been rewarded with non-cash incentives (cassava grinder). However, the number of people who benefited from these incentives was reported to be low. Additionally, the CRS forest monitoring and evaluation were very low, and the eco-guards expected extra staff support from the CRS government to manage and monitor the forest alongside them, but this was lacking. This study suggests that the forest workers may have receded in their activities because of inadequate support, resulting in ineffective forest patrol and continuous forest cover loss in the CRS.

"We are farmers, and everybody goes to their farms daily. When do we have the time even if we are asked to go? Besides, the vigilante and the eco-guards are not paid" (eco-guard 3).

"In the CRS National Park, the guards are always there. You cannot encroach if you do, you will be arrested. The rangers are always there, and at the end of the month, they are paid".

The efficiency and effectiveness of forest departments are largely determined by the performance of forest workers such as forest guards (Ojha & Gairola, 2014). Gibson et al. (2000) maintained that when forest guards are not paid adequately, they will not be motivated to perform their duties effectively. Therefore, forest users and other individuals who choose not to adhere to rules take advantage of the situation and use the forests illegally. It is worth mentioning that some forest guards contribute to deforestation through corrupt practices by accepting bribes from loggers to allow tree harvesting even under incentives. Notwithstanding, economic, and social benefits offer may significantly motivate forest guards to participate in forest conservation (Allendorf et al., 2013; Linkie et al., 2014; Phromma et al., 2019; Teye, 2013). Considering the important points raised by these authors, it is necessary for the CRS government to recognize, support, and equip eco-guards to perform their duties adequately. Likewise, the government needs to take necessary steps to protect the guards for an effective outcome. However, the quality of forest guards can only be improved in countries where forest management and conservation are viewed as serious issues.

Furthermore, the construction of a superhighway through the CRS forests was mentioned as a source of conflict. Respondents confirmed that the forest communities lack good roads to the villages. This was also observed during the collection of primary data for this study. Despite this, the people in the forest zone rejected the project. Instead, they demanded the government consult them to discuss how their forests would not be destroyed. The villagers suggested the road be constructed through the villages to preserve the forest. However, no tangible agreement was reached. The superhighway was diverted after considerable pressure at both the local and international levels (Asiyanbi et al., 2019).

> *"The government wanted to construct a superhighway through the forest. So, we in the forest zone became worried and refused. We ask them how will this be and to discuss it with us"? it is a government project and will only benefit them.*

Progress made on the ongoing forest loss issues

Respondents were questioned on any positive developments in resolving the aforementioned challenges. The result indicates that the CRS eco-guards avoided a forceful approach and assured the forest communities that the government would address the issues. Nevertheless, culprits were arrested, and relevant information was provided to the head of the forestry department, who passes it onto government officials. Additionally, complaints were made to village heads (chiefs). The local authority also arrests and used local laws to resolve disputes or punish offenders in some CRS communities. Sometimes, logging equipments were seized, and offenders fined, especially when underage trees are cut.

> *"We do not go with violence because the villagers explained that logging is what they are surviving from because the government does not care, and they must eat (eco-guard 4).*

> *"To resolve these issues, we use our local laws. In our community, we have standing local laws that govern forest management. You cannot resist our laws" (eco-guard 3).*

Further, a respondent (community elder) claimed that they were carrying out sensitization programs on the dangers of deforestation in the CRS and partnering with NGOs and international bodies such as Developments Concerns and Department for International Development in the United Kingdom. Also, a conservation club was established, with people from various LGAs now accepting membership.

"We have started selling the idea of conservation to other communities. Presently, five local government areas have accepted to join" (village elder).

Conversely, other respondents maintain that the CRS government has not been consistent enough in stopping deforestation. The interviewee claimed that the forestry team was sent to re-address the forest communities in 2016-2017 when logging activities did not stop. Unfortunately, forest conservation was not of interest to many of the villagers. They do not seem to have much trust in the REDD+ program. At this junction, the guards believed that there were limits to what they could do to protect the remaining CRS forest from further degradation.

"People are indirectly involved in this illegal activity, and yet the government is doing nothing about it. It is like they are supporting it. This means that there is nothing we can do" (eco-guard 3)

When deforestation did not stop, the forestry team was sent back to re-address the communities in 2016-2017. The villagers said they did not want to see us talking about conservation or protection in their community. They said we are all deceivers and liars. We were also threatened and told not to return" (eco-guard 1).

According to the interview, the villager's concern was that REDD+ has not benefitted them. Consequently, some people engage in logging activities with timber dealers and continued with their business as usual. As continuous deforestation was reported in the CRS, the extent and effectiveness of the penalties, local laws, and government laws in curtailing deforestation are questionable. Even though some penalties appeared to have occurred, this study revealed that they were mostly imposed after deforestation had already taken place. Handling the matter that way will not stop deforestation. Ideally, it would be better to prevent it from happening, although it may not be as simple as suggested. According to the respondents, if the CRS government provides an alternative livelihood or maintains the current one, it might be possible to stop deforestation.

6.1.2. REDD+ benefits on livelihood capitals, climate change awareness and local participation

Local participation in REDD+ climate change and REDD+ awareness

This study found that most respondents had a basic understanding of forest conservation. The relationship between forest conservation and climate change mitigation, however, did not seem to be fully grasped by many of them. Furthermore, the number of respondents that were oblivion of the REDD+ program and what it represented was high (57%). While some people were aware of and working with REDD+, 70% had not been invited to participate in REDD+. The result suggests that many of the forest communities were neither apprised nor fully integrated into the REDD+ activities. According to one of the forest guards interviewed in this study, the former governor (Liyel Imoke) held a REDD+ workshop in the CRS during his administration. There was no indication that people from different local governments were invited to participate.

The finding supports Asiyanbi (2016), Nuesiri, (2016), Krause et al. (2019) and Olaniyan et al. (2021) who argue that during the consultation and hands-on process that led to the adoption of REDD+ in Nigeria, many forest communities and local government authorities were not invited. According to this study, there is little awareness and participation in the REDD+ program within the local communities of CRS. If REDD+ is to have a positive impact and achieve its aim of forest-based climate mitigation, relevant government authorities and NGOs would need to ensure that workshops are regularly organized to create awareness of the dangers of unsustainable forest resource use in Cross River State, Nigeria, as noted by Udumo et al. (2020).

Though this is not a gender study, nevertheless, it is worth noting that the number of male respondents was more than the number of females in all the sampled communities. Recent studies have emphasised that the participation of both men and women is an important factor and a prerequisite to successful forest conservation programs. More sustainable use of natural resources is likely to be achieved by involving women because it is believed that they can manage resources better (Massey et al., 2022; Kurebwa, 2022; Bitange et al., 2021). Women are marginalized from community conservation practices even though they have the desire and knowledge to participate in conservation decision-making (Goldman et al., 2021). Gabriel et al. (2020) allude that gender-restrictive communities could lead to environmental degradation.

Consequently, the role of women in forest conservation should be considered in the Nigeria REDD+ program. This might be a contributing element to the success of the program.

REDD+ compensation and benefit on livelihood capitals

Although the CRS received some grants to start the REDD+ readiness programme in CRS (Van, 2020; Isyaku, 2017), many respondents (94%) in forest communities have not yet received compensation as shown in figure 16. The compensation rate was 6%, out of which six respondents received cash compensation. A respondent reported receiving a skills acquisition. The result is in line with Krause et al. (2019) and Nuesiri (2016) who assert that REDD+ has not provided tangible benefits to the CRS forest communities for them to have managed and used their forest more sustainably and for conservation purposes. According to Allendorf et al. (2013), the future of conservation lies in communities interested in protecting the environment and its natural resources. Payments for ecosystem services are used to compensate resource users for changing their behaviour.

Antle et al. (2002) posit that forest communities should be compensated if they support forest conservation and carbon sequestration. Conversely, Bong et al. (2016) argued that forest residents, including farmers, should be compensated when forest conservation affects their livelihood in any way. In this instance, it is worth emphasising that a country must successfully generate a verifiable carbon emission reduction through its REDD+ activities. Only when this is achieved are they eligible for payment (results-based payments) as noted by Chapman et al. (2015) and Streck (2010). Therefore, it is crucial to educate and inform all stakeholders, especially the forest-dependent communities in the CRS and beyond, about this issue. It might provide new insight into what REDD+ entails.

The development of human capital (such as skills and education) can reduce the ecological footprint by creating a culture of environmental awareness and promoting pro-environmental behaviours. Not only that but the sustainability of a country can be also improved. Therefore, investment in human skills is vital (Ahmed & Wang, 2019; Ahmed et al., 2020; Salahodjaev, 2016). Mazur & Stakhanov (2008) noted that skill acquisition might improve forest management and participation. Thus, policies that fail to take human capital into account might fail to solve climate change and other development problems (Ahmed et al., 2020). In this study, only one respondent was recorded to have received skill acquisition as compensation under REDD+. A further skill assessment was conducted to determine if respondents previously acquired any skills or training to support themselves before REDD+. Seventy-four percent of respondents did not receive any skills or training, while 26% received training related to agriculture. However, irrespective of the training areas, the number was not encouraging compared to the sample size.

It is apparent from the results that most people trained, achieved it without participating in REDD+. The result support Amuyou et al. (2021), who found that the REDD+ program trained a small number of people (6.8%) in the CRS in two different farming aspects. The conservation of forests can be positively influenced by social capital as argued by Roy et al. (2021). This study also examined the presence and activeness of social capital in the CRS. Social capital existed at a moderate level in the forest communities, and they disseminate forest conservation information. Twenty-three percent of respondents said they were empowered and supported in their efforts to reach a broader audience within their communities. The CRS appears to still be suffering from continuous deforestation despite this. Consequently, it is not clear how effective and functional these social groups are in influencing locals to stop deforestation. Although social groups do not possess the authority to force people into joining conservation movements.

According to Borg et al. (2015), information sharing, social cohesion, and mutual goals constitute social capital. This is crucial for the success of REDD+ across all levels (Ravikumar et al., 2015; Korhonen-Kurki et al., 2013). Apart from conservation purposes, social capital may reduce rural households' financial constraints, increase agricultural production efficiency, and expand entrepreneurial resources through information sharing. Moreover, it may play a crucial role in crisis and employment management (Lyons & Snoxell, 2005). It is believed that social capital might serve as an effective tool to facilitate useful information exchange among the CRS forest communities. Therefore, the focus should not only be on forest conservation for REDD+ but also on social networking and information sharing that can provide personal benefits to the villagers' livelihood in the CRS and Nigeria.

Rural areas need infrastructure to improve their quality of life and economic activities (Satish, 2007). In this study, many of the respondents (81%) did not provide an answer to the question on this area. There was no clear indication of how REDD+ has benefited them infrastructure-wise. A similar result was observed by Amuyou et al. (2021), where 93.4% of respondents expressed the view that REDD+ did not contribute to infrastructure in the CRS forest area. Nonetheless, infrastructures were likely provided through the REDD+ program based on the information provided. This study posits that communities should be informed about the types of infrastructure they have received as a result of a program. This may give them a sense of responsibility. Determining whether the infrastructures mentioned were provided by the REDD+ program, conservation NGOs, or the CRS government requires further investigation.

According to Ite & Adams (1998), residing in a forested area for a long time may contribute to slow and gradual forest loss. This study indicates that many respondents have resided in the study location for eleven to forty years. In addition to this, the household with six to ten members was high. This has implications for the CRS forests as the population increases. Furthermore, crop farming was the main source of income for the two local governments studied. It accounted for 70% of the respondents as shown in figure 4. Moreso, this study result revealed that farmers possessed farmlands of different sizes and their incomes were different. The result corroborates with Krause et al. (2019), who found that most villagers in the Boki local government were farmers and had farms to grow various subsistence crops. Thus, this study suggested that many people have a livelihood and access to natural capital in terms of land for their farming. Nevertheless, it is unknown whether they were operating under a land tenure system in which farmers permanently own their land. Therefore, the judgement on whether their livelihood is secured would be determined by the CRS land use or tenure system. This study found that the issue of land use bothers the respondents with respect to forest conservation in the CRS.

López-Carr (2021) and Zahabu (2006) maintain that local people are mostly aware of the negative impact of their actions on the forest. However, one of the major reasons they have continued to carry out these activities is that there is usually no alternative means of making an income. Not only that but livelihood decisions are shaped by factors beyond their control. Usually, they are constrained by policies governing economic subsidies, markets, and infrastructure development (ibid). Land resources promote rural livelihoods, especially in developing countries. For instance, an estimated 70% population in Africa directly depends on land and natural resources for food security and development. As such, land tenure security is an important factor that underpins the success of many multilateral policy initiatives, including REDD+. Little attention has been given to how land tenure and resource security interact with conservation initiatives (Katusiime & Schütt, 2020; Robinson et al., 2018). According to Amenu et al. (2022), lack of secure land tenure or forest user rights is the key reason local people do not commit to participating actively in forest conservation. Therefore, land tenure security issues may hinder conservation goals (Katusiime & Schütt, 2020). As such, this type of issue needs to be examined in the CRS forest community.

According to Nepstad et al. (2013), REDD+ has made little progress in engaging the agricultural sectors and farmers in their fight to protect and conserve forests for climate change mitigation. The farmers at Akamkpa and Boki LGA earned between $25 - $4,805 per annum. A significant number of respondents make between $25 - $240 per annum based on the current exchange rate. Ibok et al. (2015) reported a similar result in that many farmers in CRS earned between two hundred to for hundred thousand Naira (₦200 - ₦400). That is $480 - $960 annually. Other authors such as Bisong & Ogbonna (2018) and Ajah et al. (2017) have also recorded low farmers' income at Boki and Akamkpa LGA. Regarding the REDD+ benefit in the CRS, this study found that only 2% of respondents in two forest communities secured a loan under the REDD+ program. This level of support provided by REDD+ is diminutive. The current situation in Nigeria is characterized by high inflation and living costs as pointed out by Adu & Onwuegbuzie (2022) and Gbenga & Omo-Ojugo (2022). Therefore, the farmers' income stated above may not be adequate given inflation issues and the farmers' household size in the study areas. An additional income may be required. Training and business ideas that can improve livelihood in the CRS forest communities and Nigeria is needed.

Nepal Poudel (2014) and Maskey& Adhikari (2018) research evidenced that loan was provided to some farmers after the REDD+ pilot project was implemented in some community forestry in Dolakha, Nepal. A few studies have documented the lack of access to loans by farmers in the CRS (Etuk et al., 2018; Nwakanma &Igbe, 2020). Thus, it may be necessary to examine credit access in Nigeria's REDD+ to ensure successful forest conservation. Although this is subject to conflict and money may only be lent to businesses and farmers in areas where agricultural opportunities are better, and risk or vulnerability is lower. Hence, chances for loan recovery would be higher as explained by Das et al. (2009). Further investigation is needed to know if loan opportunity is part of the REDD+ program in Nigeria.

Socio-economic and livelihood vulnerability of the CRS forest communities

This study revealed that the CRS forest communities had a livelihood that could be improved. The high level of the households' dependence on forest resources was traceable to their socio-economic activities. The income-generating activity of most households at Akamkpa and Boki LGA was agriculture. Many farmers indicate that they desired to acquire agricultural skills and access to more land for agricultural purposes. There may be a connection between low farm income and the deforestation phenomenon. Moreover, many were not willing to migrate. Acquiring more land may have implications for the forest reserves and the future of REDD+ in the CRS. To curb deforestation and enhance conservation, previous studies have suggested alternative livelihoods (Carrilho et al., 2022; Islam et al., 2013).In the case of CRS, the issue of alternative livelihoods to agriculture might be less effective. Rather, addressing agricultural practices and land use for sustainable food production may prevent further forest degradation.

For instance, Ite (1997) found that households cleared new portions of land in the CRS forest for plantain and banana cultivation every one to three years. They believed these crops could not thrive and provide the necessary nutrient on land that had not been followed for at least 12 years. This implies they could not wait for a long time for the soil to regenerate and recover its lost nutrients. Probably the knowledge to deal with soil nutrient loss and improve yield was lacking. This type of farming practice is not sustainable. Not only climate change but unsustainable agriculture practices can lead to ecosystem vulnerability. In other words, as farmers clear virgin forests to increase crop yields instead of utilizing old farms, forest ecosystem structures are destroyed and are more vulnerable to erosion and flood (Kyere-Boateng & Marek, 2021; Meshesha et al., 2012). So, one of the solutions lies in what can be done to improve agriculture and save the remaining forests in the CRS and Nigeria as a whole.

Many African nations' economies depend on sectors vulnerable to climate conditions, such as agriculture, fisheries, forestry, and tourism (Below et al., 2010). Making a specific reference to agriculture, as a result of climate change, vulnerable people will continue to face severe droughts, dry spells, water stress, irregular rainfall, and floods. Thus, soil erosion and vegetation damage will increase. Successful food production depends on water availability, financial capital, human capital, irrigation, access to the market, literacy, quality input, technology, social learning, and other institutional infrastructure to reduce exposure and vulnerability to climate change. Otherwise, the impact of climate extremes can become detrimental to the livelihood of people who rely on agriculture for food (Adger et al., 2005; Ahumada-Cervantes et al., 2017; Alston & Pardey, 2014; DeBeurs & Brown, 2013; Fanadzo, 2012; Hanjra et al., 2009; Medugu & Skudai, 2006; McDowell & Hess, 2012)

The Cross River State is already vulnerable to the impact of climate change. This is having an impact on physical facilities (Akpan, 2010) and causing flooding in cities, rural and coastal areas, especially the low-lying areas of the CRS (Ojikpong et al., 2016; Njoku et al., 2018;

Tom et al., 2013; Obia et al, 2015). It is also causing poor crop yield in rural areas (Egbe et al., 2014). The outcome of this study was examined within the context of vulnerability. To determine whether CRS communities could cope with or prevent vulnerability during undesirable climate conditions, the REDD+ benefit based on the five sustainable livelihood capitals was examined. Literature on livelihood, vulnerability, resilience, and climate change studies (Cooper & Huff, 2018; Elmqvist et al., 2019; Gaworek-Michalczenia et al., 2022; Nyamwanza, 2012; Pelletier et al., 2016; Quandt, 2018; Wright, et al., 2012) indicates that to avoid susceptibility to climate extremes, adaptive capacity is needed. This study result suggests that the CRS forest communities may become more prone to environmental shock and climate extremes in the future. This is because the capacity needed in terms of livelihood capital assets to cope with the adverse environmental condition was inadequate. However, it is worth noting that this is not a vulnerability or resilience assessment study. The result was rather inferred passively on the existence of structures needed in this climate change era.

Looking at the preceding issue countrywide, previous studies have demonstrated that climate change is already affecting Nigeria. Recent years have seen a decline in rainfall onset and retreat periods, resulting in droughts, desertification, and nationwide flooding that is destroying properties. The impact is being felt more on agriculture in rural areas as indicated in the literature (Akande et al., 2017; Oguntunde et al., 2011; Olajide and Tijani, 2012; Ologeh et al., 2018; Onyeneke, 2019; Rose et al., 2014). For example, the flood disaster in Jalingo Metropolis of Taraba State, Nigeria was reported to have destroyed 198 farms, and 307 houses, and displaced 4,409 persons between August 2005 and August 2011 (Oruonye, 2012). Likewise, between 2011 and 2012, Ojeh and Victor-Orivo (2014) found that floods destroyed more than 50% of the total crop yield in Oleh (South-South), Nigeria.

Many rural farmers in Nigeria lack the necessary infrastructures crucial for agriculture and agro-industries development (Adeoti et al., 2014). The infrastructure provided is not sufficient despite some improvements. For instance, energy plays a vital role in economic growth, and development, as well as productive activities such as agriculture (Oyedepo, 2012). More than half of the population in Nigeria still lacks access to good electricity and the supply is very erratic (Vincent and Yusuf, 2014; Oyekale, 2012; Ibitoye and Adenikinju, 2007). While continuous investments have been made, nationwide power outages have persisted (Apinran et al., 2022). Furthermore, Nigeria’s road infrastructures are one of the least developed. When eventually constructed they do not last due to lack of maintenance. This has remained a source of serious concern (Adedeji et al., 2014; Adeoti et al., 2014; Babatunde et al., 2014; Lawal et al., 2016; Odewale, 2021; Ogunleye et al., 2018;).

Previous studies suggest that access to agricultural technology is not readily accessible in Nigeria, and it is high in cost (Agwu et al., 2008; Oladele, 2005; Pasquini et al., 2004). According to Abraham (2018), Etonihu et al. (2013), Oseni and Winters (2009) and Iyanda et al. (2014), many farm households in Nigeria's rural areas are credit-constrained and unable to insure against farm production. There are dams, especially in the Northern part of Nigeria, however, most of them are not functional. Many farmers cannot afford to operate irrigation farming systems because of cost, lack of electricity, and lack of technical knowledge to operate modern irrigation systems (Sokoya et al., 2014; Adelodun and Choi, 2018; Pasquini et al., 2004; Yusuf and Akashe, 2014).

Looking at these infrastructures in Nigeria through the adaptive capacity lens, most especially in rural communities, it seems many amenities are not readily available. The availability of these infrastructures is crucial to the overall economic development and growth of a country. Yet, Nigeria depends on rain-fed agriculture amidst the current changing climate. This can increase vulnerability and lead to a food shortage (Oladimeji and Abdulsalam, 2014). Drawing from this information, the condition in the CRS appears not to differ from other states of Nigeria. As a result of the changing climate, Nigeria needs to increase its resilience and adaptability. Therefore, the view put forward in this study is that attention should be paid to capital assets, capacity building and sustainable land use. The following paragraphs present two case studies that illustrate how vulnerable communities can build resilience.

Case studies of vulnerability reduction and resilience building

Rival (2013) discusses how REDD+ projects and other alternatives to REDD+ can improve community livelihood. The "Bolsa Floresta" in the state of Amazonas, Brazil was cited as an example. Payments for ecosystem services were used alongside programs that integrated economic and noneconomic factors into conservation activities while they worked toward carbon emission reduction. Many non-governmental and government organizations provided funds. Protected lands and conservation areas, including those inhabited by local families, were legally secured as part of the project. Using state law, a legal framework was created for the project to ensure the sharing of benefits of avoided deforestation. Incentives were offered to farmers and families with children. Additionally, a variety of income-generating, as well as capacity-building activities were undertaken. Local businesses were established, and investments were made in health, education, transportation, water, and sustainable agricultural development among others. With this in place, the community became more resilient to climate change impact. Such projects, however, require constant funding.

In the same vein, Mangroves for the Future (MFF) is another example of an initiative that focused on livelihood improvement and vulnerability reduction. The MFF aimed to restore ecosystems and strengthen coastal communities' resilience in member countries. The M.S Swaminathan Research Foundation (MSSRF), India, documented the restoration of some mangrove forests along the east coast of the country through the MFF. In many cases, the interventions enhanced the income-generating potential of existing livelihood activities. For instance, the mangrove forests in Tamil Nadu and Andhra Pradesh, India, have been degraded by clear-felling over the past several decades.

A Joint Mangrove Management programme was developed and implemented in the mangrove wetlands in collaboration with the State Forest Departments, local farmers, and other stakeholders. Villages and mangrove user communities were selected based on their resource use frequency, socioeconomic conditions, and participating intent. The project used an integrated approach. Mangrove plants, fish, crabs, prawns, and halophytes were all cultivated together. In addition to making coastal aquaculture sustainable, the project strengthens the livelihood income and resilience of coastal communities. Loan schemes and self-help groups were also created as part of the project. Other restoration techniques include bio-shields, canal-bank planting, tidal flushing, selection of climate-adaptable mangrove tree species and technical training in ecosystem restoration. More than 1,500 ha of degraded mangroves were restored through the program (Macintosh et al., 2012, p.20-196; Selvam et al., 2012).

In summary, REDD+ was designed to promote equality, capacity building, participatory governance, and social inclusion. Incentives are at the core of the REDD+ program, and it is expected to contribute to forest conservation (Basiru et al., 2022; Isyaku, 2021; Isyaku, 2017; Min-Venditti et a.l, 2017). In Nigeria, the situation is not different. REDD+ was presented to the people as a value-added program that can compensate for avoided deforestation and forest conservation (Isyaku, 2021). However, the reality of this happening seems implausible. This study indicates that the factor or motives behind the villagers' involvement in incessant deforestation and logging may not be entirely due to unmet demands for benefits as was claimed during the interview. Although it may have contributed to the conflict. This is because the CRS and Nigeria have been experiencing forest degradation for a long time before REDD+ was introduced. There is also evidence that some CRS forest communities have been practising voluntary conservation over the decades (Isyaku, 2021; Ite, 1996).

In this study, it was revealed that many people in the forest communities are farmers and there were concerned over their livelihood rather than forest conservation. In other words, they see REDD+ as a threat. Furthermore, the program was not fully engaged by many people. Many of them believed that the forest belongs to them and therefore should not be controlled or forced to manage their resources. These are major issues that need urgent attention. This study alludes that lack of fulfilment of promises made to local people before and during the establishment of conservation programs such as REDD+ may lead to withdrawal of support as seen in the case of CRS. Moreover, the use of force, incentives and payment for ecosystem services might not offer the best solution where there are no options for natural resources sustainability.

6.2. Conclusion

High hopes

To achieve success, REDD+ must create the right policy frameworks and address equity, tenure right, governance, inclusiveness, underdevelopment, institutional challenges, and the cause of resource depletion in tropical forest regions. These are some of the major issues associated with REDD+ projects. Thus, it is imperative to look beyond compensation and incentives for land users' opportunity costs because it may be too costly and inadequate as an alternative for forest conservation. Agriculture enhancement is crucial (Da-Silva et al., 2022; Den-Besten et al 2019; Kumi et al., 2014; Pacheco et al., 2010; Richards & Panfil, 2011). Conclusively, there is insufficient empirical evidence about the impacts of REDD+. Furthermore, methodological challenges exist and there is difficulty in finding an adequate control site or group for evaluation assessment (Caplow et al., 2011). The problem must be addressed. As a result. it is difficult to draw a generalized conclusion. Therefore, the REDD+ program cannot be considered a fad or a failure yet (Duchelle et al., 2018).

This study result indicates that time accounted for a 3.5% variation in the vegetation cover at Boki and Akampka LGAs. This implies that THE VEGETATION HEALTH of the study locations are likely to have improved during the time the REDD+ program was introduced. However, the qualitative findings of this study did not correspond with the quantitative result.

During the interview, the key informants assert that logging activities were still ongoing most especially at non-REDD+ sites. Although this study indicates a slight positive change in vegetation change, verification of actual ground activities capable of impacting forests positively through REDD+ site visit is needed in future research. Furthermore, it appeared that the involvement of the forest communities in REDD+ was low, and so was the social capital. Under the physical capital, only 19% of respondents claimed they received infrastructure, while 81% could not provide an answer to what REDD+ has provided. This study alludes that knowing what a program provided to a community may create a sense of responsibility. In addition, REDD+ compensation was diminutive, and many respondents are expecting to be compensated.

REDD+ safeguards support equitable benefit-sharing and pro-poor approaches because of the significant impact it might have on livelihood (Atela et al., 2015; Costenbader, 2011; Luttrell et al., 2013). However, it was found that many people could not access credit in the study area. Likewise, skill acquisition and training were very low. It appeared that respondents received training outside of the REDD+, probably from other projects in the CRS. However, the training and skills could not be said to have protected the CRS forest because many were trained in cocoa production and other crop farming. It may have prompted them to clear more forested areas. Although their livelihood, income and well-being depend on agriculture and forest resources. Such a factor cannot be ignored.

In line with the latter, natural capital showed a positive result as many respondents had access to lands of different sizes. Nevertheless, the property rights issue was not ascertained as this was not the focus of this study. Based on the outcome of this study, it could be said that many households have not remarkably benefitted from the REDD+ program to improve their well-being. Meanwhile, REDD+ and its potential benefit had been presented as an initiative that considers people's livelihood. Consequently, it was being conceived by many rural households as a program capable of relieving indigence. It is worth noting that REDD+ is a result-based payment approach. However, the initiative has created high expectations in many people's minds. This has presented a challenge to REDD+.

Beyond forest conservation

The REDD+ initiative has been termed a market-based approach to managing natural resources, biodiversity and forest conservation. Rural communities are seen as untapped ecoentrepreneurs who can minimize forest degradation and market nature for profit. Thus, they are drawn into neoliberal conservation processes under the assumption they will obtain significant socio-economic benefits. Meanwhile, the success of forest and other natural resource conservation is complex. It depends on mixed and multiple solutions such as restructuring of society–nature relations, institutional arrangements (Scheba, 2018), participation of forest communities and local dwellers (Carignano et al., 2016; Oestreicher et al., 2009), collaborative governance (Tando et al., 2022), property rights (Asiyanbi, 2016) as well as free and informed consent for safeguarding (Mukisa et al., 2020).

In addition to this, previous studies suggest that local people's attitudes toward conservation and land use are influenced by education, social groups, forest dependence, household size, farm size and farmers’ access to credit, technology, and infrastructure. Markets that directly link farmers to consumers are also a vital factor. The latter can be achieved by creating market channels for farmers to sell their agricultural products directly at a reasonable price. For instance, good access to markets and market information will help farmers bypass intermediaries and profit more. Hence, strengthening local industries and empowering smallholder farmers to access global markets is a prerequisite for farmers to generate additional income. If achieved, rural hardship and loan intake might become minimal, and their family’s nutrition will improve as they earn more money (FAO/OECD, 2011; Gatzweiler & von, 2016; Magesa et al., 2020; Sunderland et al., 2019; Wiggins & Keats, 2013; Yach et al., 2010).

Galiè et al. (2022) and FAO/OECD (2011) cited SABMiller PLC group investment program as an example of how farmers could be helped. The company provides rural barley farmers access to the beer manufacturer’s supply chain. They also provide improved seeds and inputs to farmers and bought the farm produce back from them. In this manner, the agricultural intermediaries were eliminated, and farmers received a better price which resulted in a 10% income increase. Understanding the linkages between the aforementioned factors, conservation projects, and local people may be of great value in improving forest conservation and sustainability (Kideghesho et al., 2007; Gadd, 2005).

This study suggests that a larger percentage of people in the CRS forest communities are farmers and forest resource usage may not decrease. Moreover, financial compensation may not have an in-depth impact on their household because of the amount they would receive. According to Nuesiri (2006), poverty alleviation may be attained by combining the understanding of local socio-economic dynamics. In other words, poverty alleviation in rural areas might come to realization when institutions start paying attention and working with people in a manner that align with their livelihood (Krantz, 2001). Thus, to reduce poverty and maximize farmers' potential, it has been suggested that the government should invest in building the capacity of institutions to train farmers. Furthermore, access to improved seed, financial services, and better infrastructure and other services could lead to successful food production (Baiphethi & Jacobs, 2009; Branca et al., 2021; Shanabhoga, 2022). Therefore, it would be beneficial if the CRS forest communities’ livelihood and the most-used resource is enhanced. Wickramasinghe et al. (2008) allude to this and suggest that instead of monetary compensation, forest communities should be compensated through the strengthening of sources of income.

Inadequate law enforcement

It was widely acknowledged that the CRS government placed a ban on logging activities as related earlier. Despite this, this study indicates that logging activities may still be ongoing. The continuous, and indiscriminate forest degradation indicates poor management, low law enforcement and a lack of adherence to the existing forest laws. This finding elucidates Abere & Jasper (2011) and Adekola et al. (2012) who argued that though there are existing conservation laws and policies in Nigeria, it is futile due to the non-compliance of the populace to environmental laws. The top-down approach policies added to the problem by not paying attention to the sustainability of the local people’s livelihood (Etemire & Uwoh, 2020).

Consequently, illegal, and unsustainable forest resource harvesting abounds in Nigeria (Abere & Jasper, 2011). Supposed the CRS government is keen on forest conservation and management, they need to do everything in their jurisdiction to limit logging activities. Though The Nigerian government has made some effort to educate the public about environmental issues through relevant agencies to ensure sustainable forest management in Nigeria, it has not yielded the results desired (Udumo et al., 2020). Nonetheless, environmental awareness and training must be a continuous process (Efthymiou, 2021).

Nigeria plans to implement REDD+ in Ondo, Nasarawa and Ekiti States (Asiyanbi & Massarella, 2020; Adekugbe, 2020). The implementation and progress of the program in the three states are rarely discussed in the literature. Probably because REDD+ was only introduced to the new states in 2015 (Isyaku et al., 2017) and it is still in its infancy. As evidenced in this study, detailed research must precede the implementation of any REDD+ project to establish socioeconomic status, level of dependence on forest resources and skill preference that needs improvement in the local community. Prior to the REDD+ in Nigeria, deforestation and degradation in forest reserves, woodlands, and national and wildlife Parks have been widely reported in the literature (Alamu & Agbeja, 2011; Aweto, 1990; Faleyimu, & Oyebade, 2012; Fitz et al., 2022; Lowe, 1984; Numbere et al., 2022; Otum et al; 2017). This has been tagged majorly on agriculture and timber logging. Although some community members do participate in conservation projects in Nigeria, support has been low (Digun-Aweto et al., 2019; Ite, 1996; Ite, 1998; Ite & Adams, 2000). The low support for forest conservation, deforestation, and the lack of necessary amenities for resilience building in rural areas indicates that the ongoing problems in the CRS are similar to those in other parts of Nigeria. Therefore, the implication of this study applies to other Nigerian states and African countries with similar forest conservation initiatives challenges.

In summary, this study suggests that the factors contributing to incessant forest cover loss in the CRS were likely beyond incentives, anger, and the use of force in tree harvesting. Other factors may have contributed to this problem, including livelihood concerns and a lack of support for eco-guards and forest communities. The aim and objective(s) of REDD+ are to contribute to climate change mitigation action globally. The Federal Government of Nigeria has made a commitment towards this via the REDD+ program but it appears climate change mitigation effort in the CRS lacks a firm mechanism to incorporate local livelihood sustainability and participation.

There were indications that these challenges have not been decently addressed as the REDD+ program has not offered any tangible benefit to the CRS forest communities. Additionally, people that were aware of REDD+ seemed to have lost interest in the program. As a result, Nigeria may not be able to contribute meaningfully to climate change mitigation. The goal may be undermined or unreachable unless certain strategies and plans are implemented. The CRS government should therefore take steps to improve the livelihoods of the local communities to conserve and manage the remaining tropical rainforest and save endangered and rare primates in Nigeria. Training and skill acquisition in areas other than agriculture is vital to create diverse knowledge and businesses among the CRS forest communities.

Nigeria is the most populous nation in Africa and as the population increases so is agriculture intensification (Usman & Nichol, 2022), especially since the food importation ban. As a result, there may be more forest clearing at a faster pace which may cause more damage to the environment. Loss of biodiversity can result from poorly managed agricultural systems as stated by Tscharntke et al. (2012). Most farmers are already vulnerable to the impact of climate change in Nigeria and may become more prone in the future. The adaptive capacity to keep up with people's livelihood and manage farms is not readily available. Information and targeted solutions are needed to address these interrelated issues because it has implication for the REDD+ program. Therefore, the view put forward in this study is that attention should be paid to capital assets and consideration should be given to the sustainable use of land for crop production. It was on these bases some recommendations were made in this study.

6.3. Findings highlight/key message

The interview outcome suggests that most of the forests that were supposed to be intact in CRS were being degraded and decreasing daily. However, this contradicted the remote sensing result, indicating a positive change in vegetation cover at the REDD+ LGA. Furthermore, the people involved in the logging business were sometimes armed with weapons. Thus, it was hard for forest eco-guards to act against further forest degradation appropriately. Additionally, the eco-guards were not paid a salary. This made them recede in their activities to protect the forest. Conflicts emanated from the CRS government's failure to offer royalty to the forest communities, deliver entrepreneurship skills and provide loans for forest users to establish businesses.

More than 60% of respondents understood the concept of forest conservation. However, a lot of people were not aware of the REDD+ program, and 71% specified that they had not been invited to participate. Eighty percent believed their forest should be conserved. Nevertheless, they appeared to be displeased with forest conservation through the CRS government. Furthermore, 67% desire more land for agricultural purposes and hope to be trained in the same area. Likewise, 94% had not received compensation, while many could not secure a loan through the REDD+ program. It was found that most of the respondents were not willing to migrate from the forest areas and the issue of forest conservation bothered them.

6.4. Recommendation

- Mazur and Stakhanov (2008) stated that achieving natural resource management and sustainable agriculture requires collaborative learning, problem-solving, and co-management. This study proposes that farmers should be trained in sustainable farming practices and yield maximization methods on existing agricultural lands.
- As Trædal & Vedeld (2018) suggest, policymakers need to identify context-specific approaches and integrate local communities' socioeconomic realities, existing social institutions, and agricultural practices with the ambitious conservation goals of increasing forest carbon stocks. Achieving the integration of goals will involve a multi-stakeholder approach and intersectoral policy convergence that the current REDD+ program in Nigeria lacks. Policymakers need to understand the unique demands and socioeconomic interactions of forest communities with the forest and its resources. This will help design effective interventions that feed into global conservation goals.
- Smallholder farmers should be empowered and linked to both local and international markets. By doing so, they can sell directly to consumers and generate additional income. In addition, fair trade should be promoted and ensure that the trade benefits farmers who are marginalized from wealth generation.
- Awareness should be created regarding forest conservation, REDD+, and climate change. However, some individuals within the forest communities may not be able to interpret technical information or have access to technology. In light of this, information, education, and communication (IEC) materials should be produced in local languages. This can maximize their appreciation of the REDD+ values as well as their knowledge of climate change and positively impact conservation. A local-language IEC example the local language is the **“**Building Institutional Capacity and Participatory Leadership in Awash and Simien Mountains National Parks for Resilience, Mitigation and Adaptation to Climate Change (BICAS-RMACC)” project, Ethiopia (Assaye, 2014).
- Before implementing conservation programs such as REDD+ in Nigeria, the government and stakeholders need to identify the key biodiversity parameters and quantitative approaches to assess the vegetation cover change in the forests. Likewise, baseline data for sustainable forest management should be a crucial yardstick used by implementers of interventions and policymakers to capture and monitor the progress made in the interventions. Furthermore, policymakers and conservation managers can

adopt advanced methods, for example, using randomized controlled experiments to measure the counterfactuals and determine the direct contribution of an intervention to forest conservation.

- As Chukwuone et al. (2020) suggested, there is a need to incorporate indigenous forest management techniques in policy-led interventions and programs. In addition, the user rights of forest communities need to be comprehensively defined by including aspects of private property rights in the country's standard property resource management scheme.
- The role of financial inclusion in enhancing farmers' resilience to climate-related shocks is crucial. In Nigeria, Iyanda et al. (2014) and Nwosu et al. (2020) found that farmers rely on community organizations such as farmers' savings societies to deal with a lack of credit, but it is insufficient. Therefore, formal financial institutions should create insurance products that leverage local networks in the CRS.
- Vocational and technical skills should be developed among youth. Youth can be trained to act as facilitators in raising awareness and promoting environmental awareness in schools and colleges (Poffenberger, 2014).
- Establish active monitoring measures to prevent illegal forest activity. Furthermore, conservation should be incorporated into national programs, policies, legislation, and school curricula. By doing so, a wider learning environment could be created.
- Nigeria REDD+ should prioritize livelihood improvement by providing basic infrastructure, loans, and capacity building. This can encourage them to support and contribute to forest conservation.

6.5. Study Contributions

This research has adopted a quantitative assessment approach to account for the impact of REDD+ in Nigeria using a dataset of the pre-REDD+ and post-REDD+ Normalised Difference Vegetation Index (NDVI) from 2009 to 2019. There was a lack of data to evaluate the REDD+ program in Nigeria. Therefore, this research recommends rigorous data collection and evaluation methods for future conservation interventions. Additionally, the data should be made open to the public so that researchers can access them. As part of what was considered essential before REDD+ implementation, this study provided information on the type of livelihood training the forest communities would be pleased to receive and the adaptive capacity support to cope with climate extremes, which of course was inadequate. This type of research on skill or training preference may facilitate essential plans and reveal potential areas for livelihood capacity-building development to reduce deforestation and contribute to climate change mitigation.

Furthermore, this research contributes to academic knowledge by describing a method that captures and assigns daily mean NDVI data to each municipal (local government area) of a country using an administrative boundary map and the NOAA AVHRR NDVI data. This can be used to complement qualitative data in future studies. Not only that, but it also suggests that the use of NDVI data might not provide enough information about forest issues. A site-specific visit and data collection may be needed. Nigeria lacks rigorous research on deforestation interventions. This study may provide useful information for effective decision-making among policymakers, NGOs and other stakeholders involved in forest conservation and REDD+. In addition, the findings may inform decisions on the design and implementation of future forest conservation programs in Nigeria and other counties with similar issues.

6.6. Research limitations

In Nigeria, there was a paucity of current data on population and agricultural data for example. Thus, interview and secondary data were used to complement the qualitative data (NDVI data) in this study. Additionally, the villages where the study was conducted had poor road networks and were very remote. To connect between villages within the two local government areas of Cross River State, enumerators had to walk a long distance to find a motorbike or vehicle. Consequently, the number of questionnaires collected within the given timeframe was reduced. Additionally, some respondents believed that this study was funded by the United Nations and expressed concern that nothing has been done to assist them. As a result, few people declined to participate in the study.

Further research

In this study, the quantitative result using the Normalized Difference Vegetation Index (NDVI) was different from the interview findings. This is a major outcome that needs an answer. However, what brought about the CRS vegetation improvement was not ascertained. The forest may have been positively impacted by some ground activities, but the sites were not visited for verification. It is also necessary to understand REDD+ implementation in Nigeria, particularly in the CRS and how they account for their impact. Therefore, further research is needed into these areas. Additionally, it is important to investigate the local capacity-building preferences in other Nigeria REDD+ sites to understand their interests and provide training accordingly rather than a generalised livelihood program. This study provided limited information; comprehensive research is necessary for effective decision-making in Nigeria's REDD+ and other forest conservation programs. Moreover, the CRS forests are sanctuaries for rare and endangered species of animals. A careful study of their numbers may provide important information concerning the type of assistance conservationists should seek for their safety.

Data collection

Due to Covid 19 restrictions, the author of this study was not permitted to travel. Therefore, the data were collected using research enumerators in Nigeria in persons of Dr Lauretta Ofodile, Yaba College of Technology Lagos State, Nigeria, Nwaeche Chiemerie and Gabriel Otolorin, University of Uyo, Akwa Ibom State, Nigeria.

Positive results of the fieldwork

The language barrier was minimal as respondents communicated in the English language except for a very few elderly people who interacted in pidgin English.

Funding

This research received no external funding.

Conflicts of interest

The author declares no conflict of interest.

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Appendices

Appendix 1: Descriptive statistics result for normal distribution in Excel

Table 1. Mean NDVI used for the trend analysis

Unequal data	Year	Mean NDVI		Year	Mean NDVI	
		AkamkpaLGA	Boki LGA		Akamkpa LGA	Boki LGA
	2000	0.359752	0.433811	2010	0.353987	0.455184
	2001	0.32539	0.434679	2011	0.33042	0.452108
	2002	0.300338	0.408013	2012	0.295111	0.411813
	2003	0.267491	0.389973	2013	0.262591	0.370624
	2004	0.275996	0.380512	2014	0.298263	0.39852
	2005	0.261834	0.391336	2015	0.315754	0.382196
	2006	0.346623	0.438687	2016	0.24841	0.34249
	2007	0.295916	0.414486	2017	0.228171	0.309782
	2008	0.286702	0.355597	2018	0.218255	0.332737
	2009	0.375833	0.495685	2019	0.117226	0.415402

Table 2. Descriptive statistics for Akamkpa LGA

AKAMKPA (PRE-TEST)		AKAMKPA (POST TEST)	
Mean	0.309654	Mean	0.273894
Standard Error	0.007273	Standard Error	0.007324
Median	0.313945	Median	0.259655
Mode	#N/A	Mode	0.470256
Standard Deviation	0.127432	Standard Deviation	0.126002
Sample Variance	0.016239	Sample Variance	0.015877
Kurtosis	-0.74441	Kurtosis	-0.57893
Skewness	0.025984	Skewness	0.304027
Range	0.58058	Range	0.641662
Minimum	0.038322	Minimum	-0.00832
Maximum	0.618902	Maximum	0.633343
Sum	95.06386	Sum	81.07267
Count	307	Count	296

Table 3. Descriptive statistics for Boki LGA

BOKI (PRE-TEST)		BOKI (POST-TEST)	
Mean	0.41448	Mean	0.385746
Standard Error	0.008112	Standard Error	0.008415
Median	0.429801	Median	0.382946
Mode	#N/A	Mode	0.621325
Standard Deviation	0.142131	Standard Deviation	0.144776
Sample Variance	0.020201	Sample Variance	0.02096
Kurtosis	-0.67681	Kurtosis	-0.29722
Skewness	-0.38436	Skewness	0.157466
Range	0.659731	Range	0.833785
Minimum	0.052765	Minimum	0.071402
Maximum	0.712496	Maximum	0.905187
Sum	127.2453	Sum	114.1809
Count	307	Count	296

Appendix 2: Figures and tables for the time series analysis

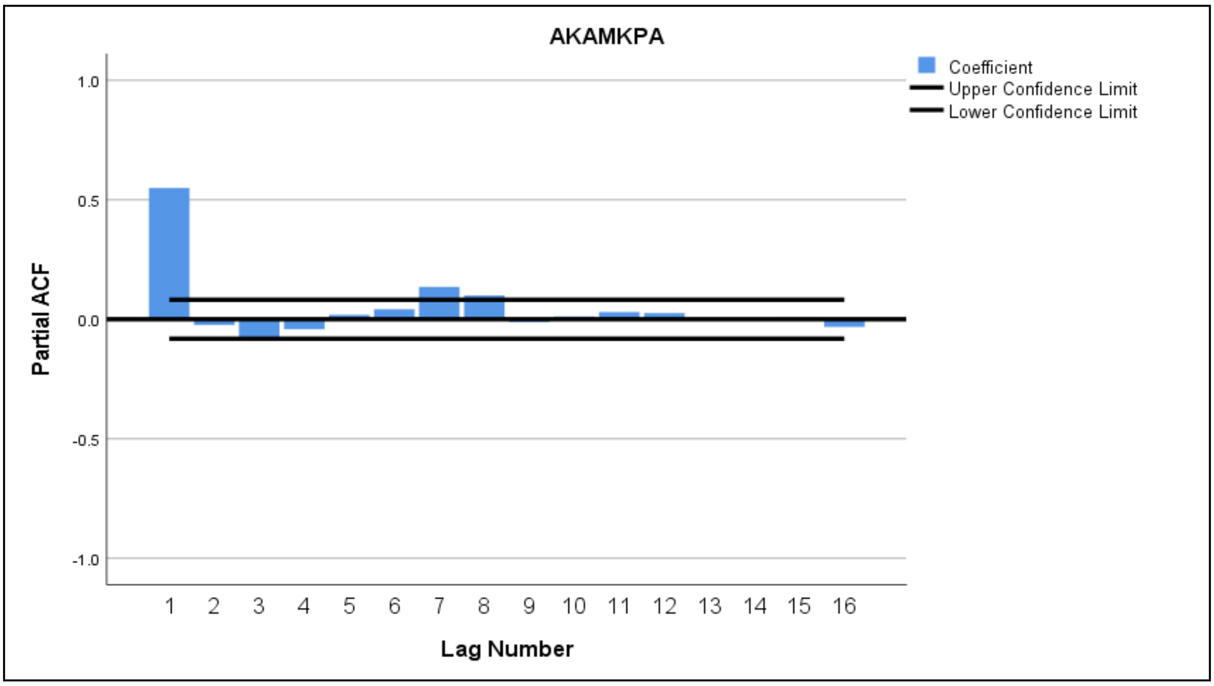


Figure 1: Autocorrelation limit test for Akamkpa LG NDVI

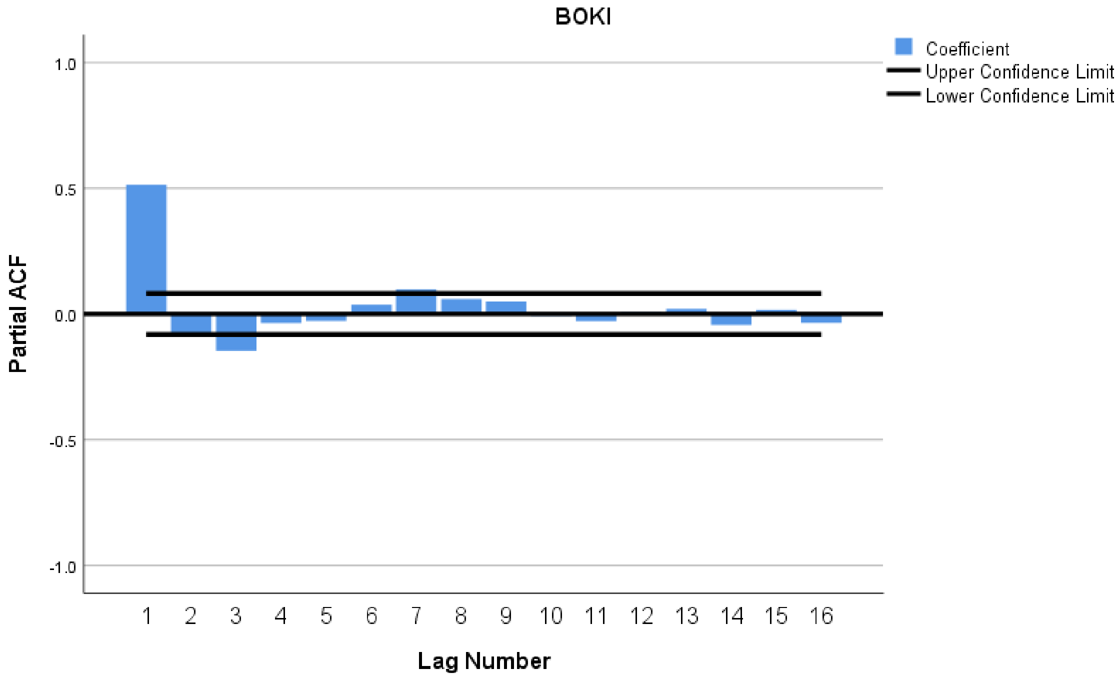


Figure 2: Autocorrelation Test for Boki LG NDVI

Table 1: Model Fit

Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.303	.021	.288	.318	.288	.288	.288	.303	.318	.318	.318
R-squared	.303	.021	.288	.318	.288	.288	.288	.303	.318	.318	.318

Fitting an ARIMA model for the pre-intervention period, it is observed that time explains 32% of the variation of the model. The explanatory power of time is relatively strong (having a minimal standard error).

Table 2: Model Statistic

Model Statistics

		Model Fit statistics		Ljung-Box Q(18)			
Model	Number of Predictors	Stationary R-squared	R-squared	Statistics	DF	Sig.	Number of Outliers
AKAMKPA-Model_1	0	.318	.318	16.684	16	.406	0
BOKI-Model_2	0	.288	.288	16.445	14	.287	0

a. Best-Fitting Models according to R-squared (larger values indicate better fit).

Table 3: Arima Model Parameters

ARIMA Model Parameters

					Estimate	SE	t	Sig.
AKAMKPA-Model_1	AKAMKPA	No Transformation	Constant		.292	.011	27.175	.000
			AR	Lag 1	.540	.034	15.681	.000
			MA	Lag 8	-.154	.041	-3.780	.000
BOKI-Model_2	BOKI	No Transformation	Constant		.401	.008	51.081	.000
			AR	Lag 1	1.081	.159	6.785	.000
				Lag 2	-.503	.082	-6.151	.000
			MA	Lag 1	.549	.164	3.358	.001
				Lag 2	-.215	.081	-2.635	.009

a. Best-Fitting Models according to R-squared (larger values indicate better fit).

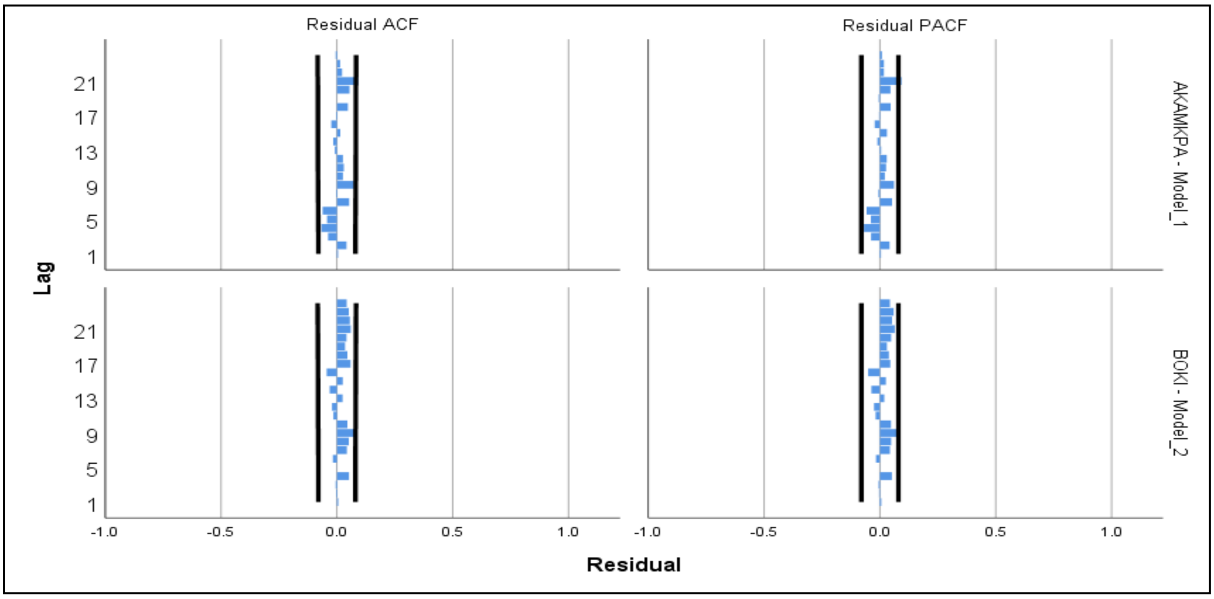


Figure 3: Residual Graph for Each Model

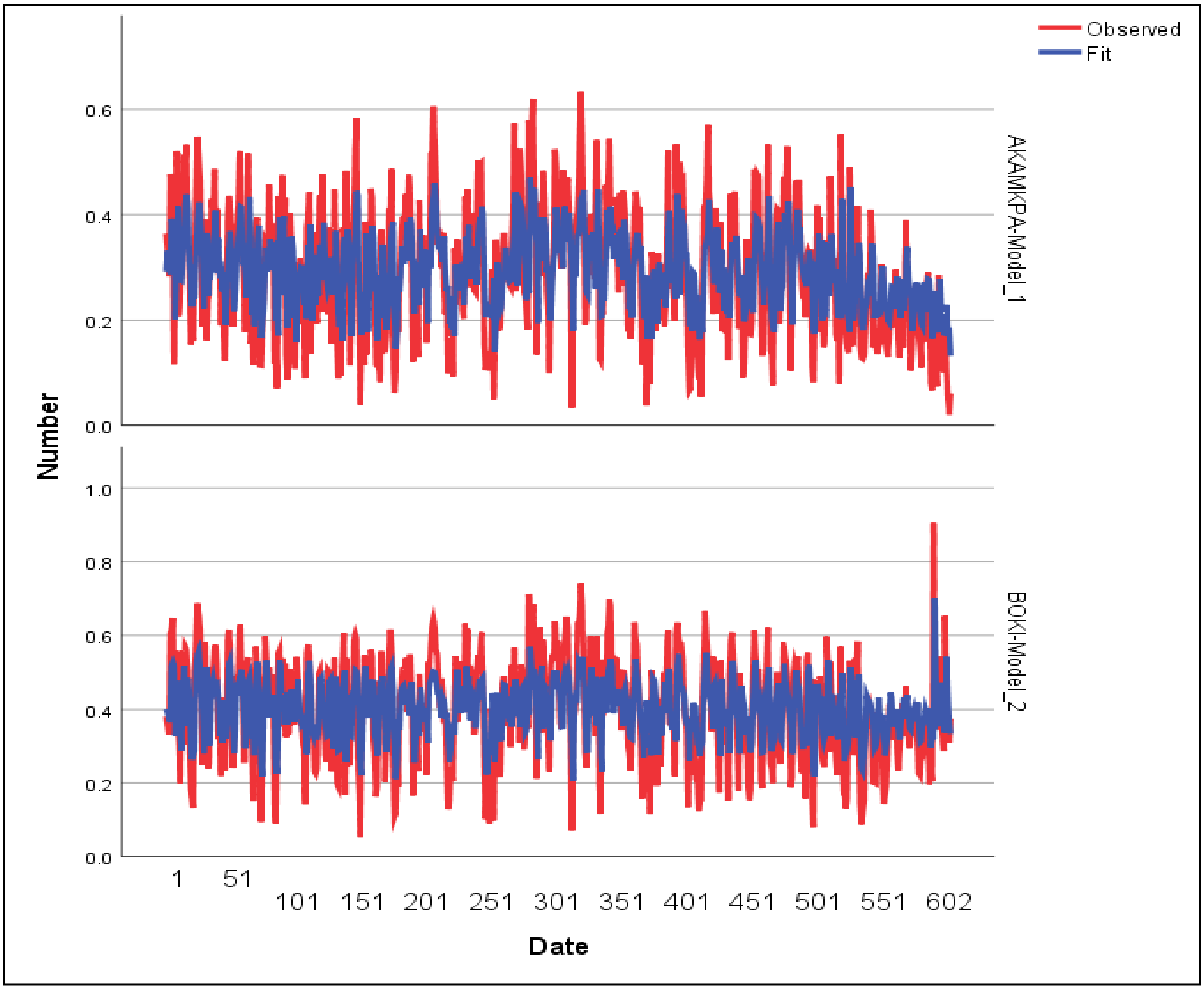
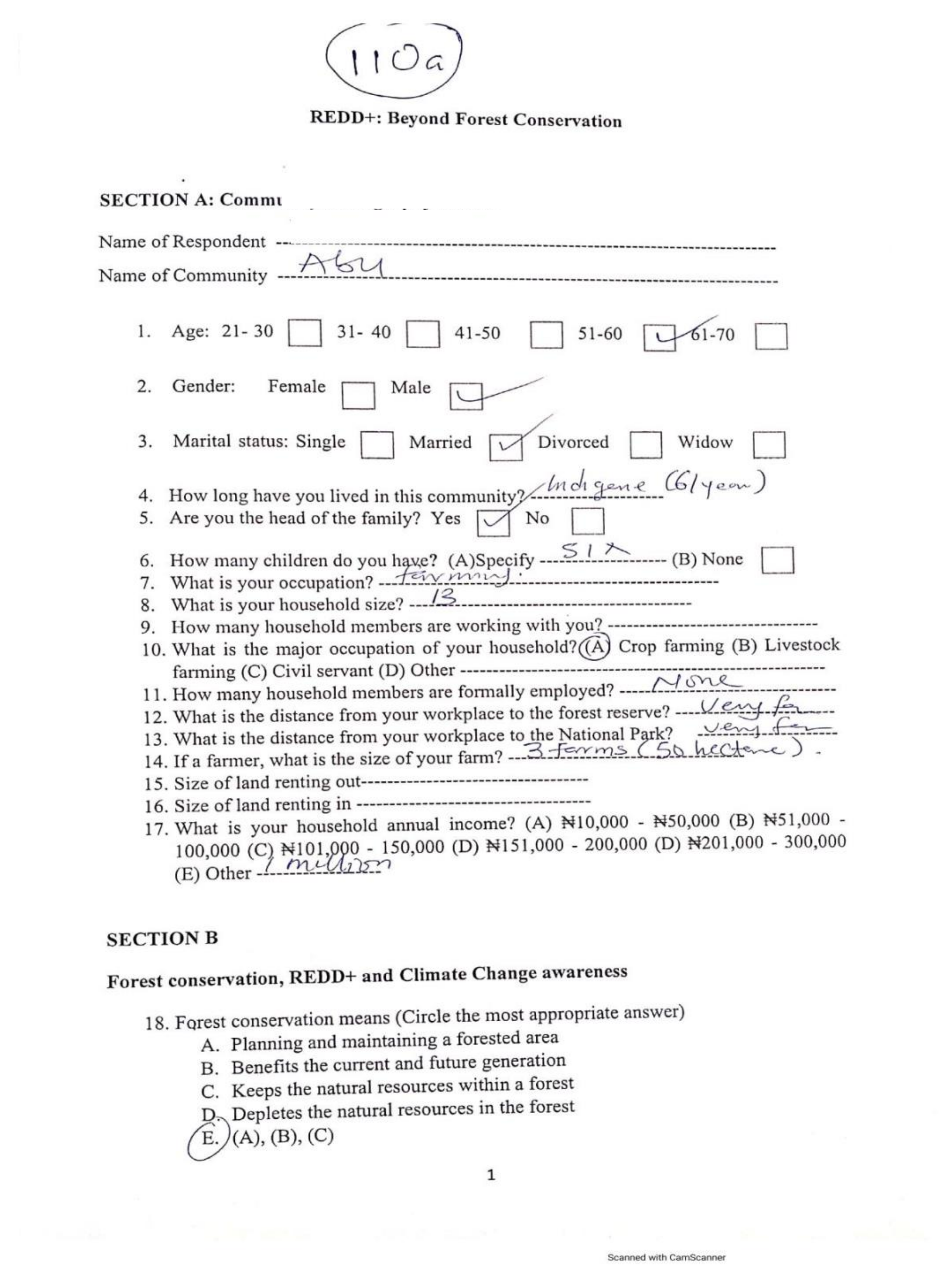


Figure 4: Observed Values versus the Fitted model

Appendix 3: Interview Questions

- What challenges do you face as a guard in protecting the forest in Cross River State?
- Has the forest coverage in CRS increased since the REDD+ intervention, or is it decreasing?
- How are the forest communities supporting REDD+ in the CRS?
- What have you achieved through the REDD+ program in your community?
- Is there any factor causing conflict between the forest communities and the conservation authority in CRS?
- How have you resolved the conflict and dealt with deforestation in CRS?

Appendix 4: A Copy of the questionnaire for this study



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REDD+: Beyond Forest Conservation

SECTION A: Commu

Name of Respondent --

Name of Community ---Abu---

1. Age: 21- 30 ☐ 31- 40 ☐ 41-50 ☐ 51-60 ☑ 61-70 ☐
2. Gender: Female ☐ Male ☑
3. Marital status: Single ☐ Married ☑ Divorced ☐ Widow ☐
4. How long have you lived in this community? Indigene (61 year)
5. Are you the head of the family? Yes ☑ No ☐
6. How many children do you have? (A)Specify ---SIX--- (B) None ☐
7. What is your occupation? ---farming.---
8. What is your household size? ---13---
9. How many household members are working with you? --------------------------------
10. What is the major occupation of your household? [✓ (A)] Crop farming (B) Livestock farming (C) Civil servant (D) Other ---
11. How many household members are formally employed? ---None---
12. What is the distance from your workplace to the forest reserve? ---Very far---
13. What is the distance from your workplace to the National Park? ---Very far---
14. If a farmer, what is the size of your farm? ---3 farms (50 hectare).
15. Size of land renting out-----------------------------------
16. Size of land renting in -----------------------------------
17. What is your household annual income? (A) ₦10,000 - ₦50,000 (B) ₦51,000 - 100,000 (C) ₦101,000 - 150,000 (D) ₦151,000 - 200,000 (D) ₦201,000 - 300,000 (E) Other ---1 million---

SECTION B

Forest conservation, REDD+ and Climate Change awareness

18. Forest conservation means (Circle the most appropriate answer)
    - A. Planning and maintaining a forested area
    - B. Benefits the current and future generation
    - C. Keeps the natural resources within a forest
    - D. Depletes the natural resources in the forest
    - [✓ E.] (A), (B), (C)

1

Scanned with CamScanner

1106

19. Do you know the benefit of conserving the forest? Yes ☑ No ☐

20. If yes, have you received awareness on the usefulness of forest conservation in mitigating climate change? Yes ☑ No ☐

21. Have you ever heard about REDD+? Yes ☐ No ☑ (Heard about them but hardly see them.

22. REDD+ policy is the effort of the Government to do the following
    A. Increase emission from deforestation
    B. Minimise emission from deforestation and forest degradation
    C. Minimise the impact of climate change
    D. Increase forest degradation and deforestation
    E. (B), (C)

Level of participation of the forest community in REDD+

23. Have you ever been notified or get invited to participate in REDD+ in your community? Yes ☐ No ☑

24. If yes above, are you involved in the REDD+ program in your community?
    Yes ☐ No ☐

25. If yes, in what way are you working with REDD+? (Tick the correct option)
    A. Member of the forest Monitoring Team
    B. Awareness team
    C. Forest Protection Task Force
    D. Other --------------------------

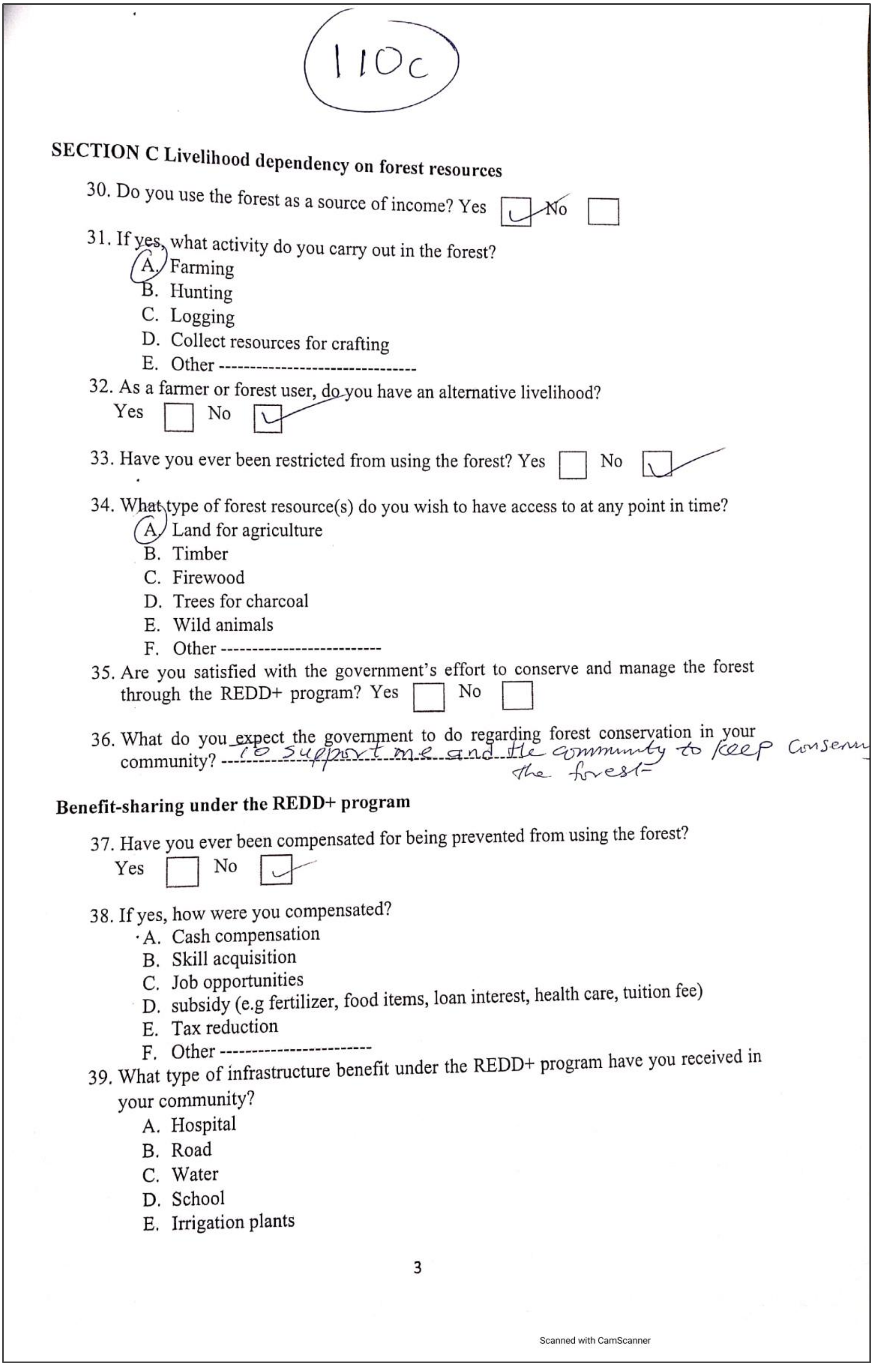
26. How do you evaluate your participation in forest management?
    A. Very active
    B. Active
    [✓ C.] Less active

Social group and networking

27. Is there any forest management and conservation group in your community?
    Yes ☑ No ☐

28. Do you share information among yourselves? Yes ☑ No ☐

29. Does forest conservation and management under the REDD+
    [✓ A.] Ensured the empowerment and support of the group
    B. Ensured the empowerment and support of individual people
    C. Empowerment of women
    D. No empowerment or support at all



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SECTION C Livelihood dependency on forest resources

30. Do you use the forest as a source of income? Yes ☑ No ☐

31. If yes, what activity do you carry out in the forest?
    - [✓ A.] Farming
    - B. Hunting
    - C. Logging
    - D. Collect resources for crafting
    - E. Other -------------------------------

32. As a farmer or forest user, do you have an alternative livelihood?
    Yes ☐ No ☑

33. Have you ever been restricted from using the forest? Yes ☐ No ☑

34. What type of forest resource(s) do you wish to have access to at any point in time?
    - [✓ A.] Land for agriculture
    - B. Timber
    - C. Firewood
    - D. Trees for charcoal
    - E. Wild animals
    - F. Other -------------------------

35. Are you satisfied with the government's effort to conserve and manage the forest through the REDD+ program? Yes ☐ No ☐

36. What do you expect the government to do regarding forest conservation in your community? To support me and the community to keep Conserv the forest-

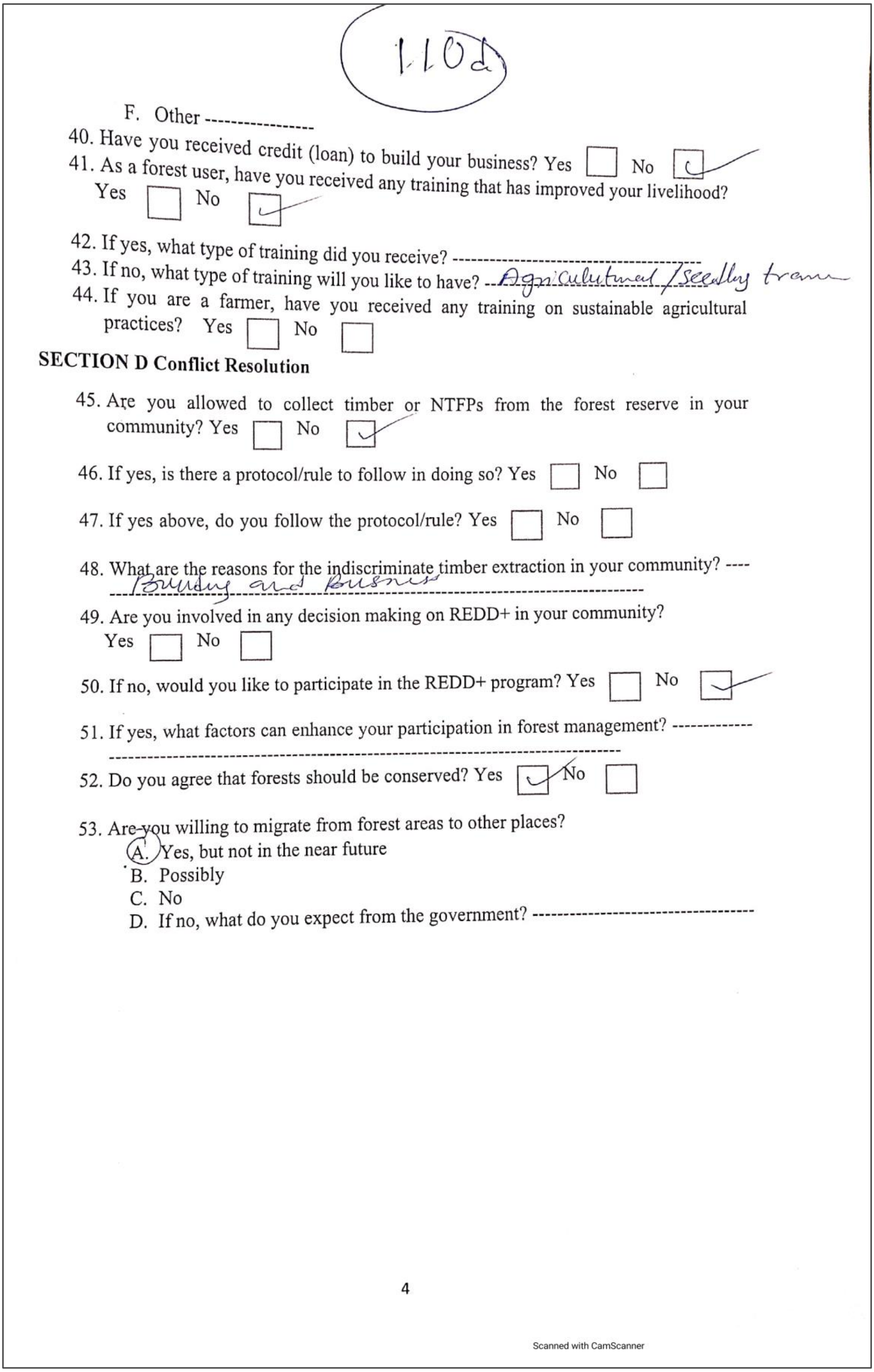
Benefit-sharing under the REDD+ program

37. Have you ever been compensated for being prevented from using the forest?
    Yes ☐ No ☑

38. If yes, how were you compensated?
    - A. Cash compensation
    - B. Skill acquisition
    - C. Job opportunities
    - D. subsidy (e.g fertilizer, food items, loan interest, health care, tuition fee)
    - E. Tax reduction
    - F. Other ------------------------

39. What type of infrastructure benefit under the REDD+ program have you received in your community?
    - A. Hospital
    - B. Road
    - C. Water
    - D. School
    - E. Irrigation plants

3



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F. Other ----------------

40. Have you received credit (loan) to build your business? Yes ☐ No ☑

41. As a forest user, have you received any training that has improved your livelihood?
Yes ☐ No ☑

42. If yes, what type of training did you receive? --

43. If no, what type of training will you like to have? --Agricultural /Seedling train

44. If you are a farmer, have you received any training on sustainable agricultural practices? Yes ☐ No ☐

SECTION D Conflict Resolution

45. Are you allowed to collect timber or NTFPs from the forest reserve in your community? Yes ☐ No ☑

46. If yes, is there a protocol/rule to follow in doing so? Yes ☐ No ☐

47. If yes above, do you follow the protocol/rule? Yes ☐ No ☐

48. What are the reasons for the indiscriminate timber extraction in your community? ----
Building and Business

49. Are you involved in any decision making on REDD+ in your community?
Yes ☐ No ☐

50. If no, would you like to participate in the REDD+ program? Yes ☐ No ☑

51. If yes, what factors can enhance your participation in forest management? ------------
----

52. Do you agree that forests should be conserved? Yes ☑ No ☐

53. Are you willing to migrate from forest areas to other places?
    - [✓ A. Yes, but not in the near future]
    - B. Possibly
    - C. No
    - D. If no, what do you expect from the government? ----------------------------------

Appendix 5: Figures 1 and 2 depict the primates' pictures at the study locations in CRS, Nigeria.

Figure 1: Primates' picture, Wildlife Sanctuary, Boki LGA, CRS, Nigeria.

Figure 2: Primates' statue, Boki LGA, CRS, Nigeria.